Screening Level Assessment of Alternative Development

Exeter, Rhode Island

Final Report, August, 2005

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Screening level assessment of alternative development, Exeter RI

1.0 INTRODUCTION

Objectives

The University of Rhode Island (URI) Cooperative Extension, Nonpoint Education for Municipal Officials (NEMO) Program, in partnership with the Exeter Economic Development Commission, conducted an analysis of alternative development options for the Route 2 and former Ladd School areas of Exeter, Rhode Island (Figure 1). This report describes the assessment approach, summarizes findings, and provides supporting technical documentation.

The purpose of this project is to evaluate potential impacts of development at the former Ladd School site, compare pollution risks associated with redirecting growth to a nearby site on RI Route 2, and identify management practices to enhance protection of local water resources. Our objectives are:

- To evaluate potential impacts of current and future growth of the Ladd School site based on current plans and zoned land use.
- Compare potential impacts of redirecting growth from the Ladd School area to the nearby Rt. 2 commercial district as a hypothetical location for a compact, mixed commercial/residential village center in a less environmentally sensitive site.
- Evaluate effectiveness of alternative pollution controls in reducing pollution risk.
- Review results of nutrient loading models applied in the Ladd School area, and summarize general findings on the capability of the Ladd site to accommodate additional growth.

This project was initiated by Exeter local officials because of concerns regarding future impacts of more intense use of the Ladd School site given it's location within the town's primary groundwater reservoir and it's proximity to the Queens River – a regionally significant river system valued for it's rare and unique aquatic habitat. In addition, town officials were interested in exploring new approaches to land development design that favor concentrating economic development in dense growth centers to make efficient use of water and wastewater infrastructure, while protecting surrounding open space.

About URI Nonpoint Education for Municipal Officials

URI Nonpoint Education for Municipal Officials, or NEMO for short, is a Cooperative Extension outreach program that provides training and watershed assessment tools to assist RI municipal officials in managing local water resources. In this project our goal is to provide information Exeter town officials can use to identify potential risks to water quality with growth and select effective pollution controls to balance economic development goals with resource protection needs. This information is provided strictly to support town officials in making informed decisions regarding the best course of action to protect local groundwater supplies and the Queens River system. URI NEMO has no interest in and does not take a position regarding the type or location of development, nor do we advocate use of any particular technology for stormwater management or wastewater treatment.

Risk Assessment Approach

This project applies the Cooperative Extension MANAGE risk assessment method to conduct a screening level review of pollutions risks from current land use and proposed future development using computer-generated maps, known as geographic information system (GIS) databases. MANAGE, short for the Method for Assessment, Nutrient Loading And Geographic Evaluation, is a GIS-based decision support tool designed to explore the relative change in pollution risk under different development intensities and with use of realistic pollution control practices. Designed for small watersheds and aquifer recharge areas, the method was adopted by the RI Department of Health (RI HEALTH) in assessing and ranking threats to drinking water supplies under the RI Source Water Assessment Program. This assessment is designed to identify and rate threats to both surface and groundwater resources. The focus is on the Queens River system and associated groundwater resources, which provide the sole source of water supply for public and private wells.

The MANAGE approach is a relatively low cost assessment designed to support local land use decisions. It generates information on likely sources of pollution focusing on major threats to the most sensitive resources. This approach is based on the premise that the cause and effect relationship between land use activities and resulting water quality impacts is often very difficult to verify. Monitoring provides the most direct evidence of existing conditions but field investigations are expensive and results often inconclusive. Variability in the natural environment, gaps in our understanding of the transport and fate of pollutants in the environment, unknowns about the type of pollutants that may be generated, and uncertainties about future operation, maintenance and performance of onsite wastewater treatment systems, all make predicting impacts uncertain at best. Because of these uncertainties, the assessment focuses on identifying and ranking pollution risks rather than quantifying potential impacts relative to monitored data. Although we briefly describe the water resources in the study area, it is the town that determines the value of these resources and establishes protection priorities through the comprehensive plan and land development regulations. Local decisions such as the type and intensity of activity allowed and the level of pollution control required are therefore ultimately based on the value assigned to these resources and town officials' willingness to accept some degree of impact in order to achieve other town goals, such as economic development or providing affordable housing.

Using land use and soils information derived from the Rhode Island Geographic Information System (RIGIS), we used a variety of indicators to relate study area land use and landscape features with potential impacts to water resources. These indicators include for example, the percent impervious cover of the study area, and estimated average annual runoff and nutrient loading. The MANAGE risk assessment results are best used to compare the relative change in among different land uses and pollution control practices, rather than direct comparison with monitored data.

To evaluate existing conditions, readily available monitoring data and previous studies were collected and reviewed. Because this is an overview of pollution risks based on existing information, no new field investigations were conducted. Other nutrient loading models have been applied to evaluate impacts of development at the Ladd School site, and from the Job Corps onsite wastewater treatment system specifically. To better understand and build on this body of work, we expanded this project to compare our results with modeling methods, assumptions and results of these previous studies.

The study areas were selected in cooperation with the Exeter Economic Development committee in September 2004. Land use maps created from the Rhode Island Geographic Information System (RIGIS) were updated using corrections provided by these volunteers and field investigations by URI staff. Pollution risks were evaluated for current land use and future development based on proposed growth projections at the former Ladd School site. The Route 2 area, where a post office and small commercial strip center is currently located, was evaluated as

an alternative growth center where future growth might be re-directed using compact, village-type development designed to preserve surrounding fields and open space by avoiding low-density, scattered development over a larger area. This is a strictly hypothetical scenario selected to explore an alternative to development at the Ladd school site, further removed from the environmentally sensitive Queens River but with direct highway access and visibility to attract investment. In both areas, pollution threats were mapped and the relative effectiveness of stormwater controls, reduced impervious cover, and advanced wastewater treatment were evaluated.

2.0 STUDY AREAS

Two primary study areas were chosen for assessment of pollution risks: 1) the Ladd School Study Area and the 2) Village Study Area. These Wellhead Protection Areas (WHPAs) were selected to evaluate the potential impacts of current and future development within these critical areas. This approach is in keeping with wellhead protection methods used in the RI Source Water Assessment Program and other state groundwater protection programs. For example, the MA Department of Environmental Protection Groundwater Program requires communities to conduct a groundwater nitrogen nutrient loading analysis using the same type of mass balance approach employed by the MANAGE method to identify areas at risk of elevated nitrogen concentrations.

In addition, two secondary areas were evaluated. The full Queens River watershed (Figure 2) was analyzed as a relatively undeveloped “reference” watershed representing conditions with low pollution risks and relatively unimpaired water quality. The Chipuxet River watershed was also used, as a reference for the Village study area. In addition, GIS map analysis was extended beyond the study wellhead areas to evaluate potential impacts to local water resources from alternative development options that may extend outside the two primary wellhead protection areas.

2.1 Ladd School Study Area

The Ladd School Study Area is the non-community wellhead protection area (WHPA) corresponding to the well for the Marathon House, a drug rehabilitation center currently in operation on the former Ladd School property (Figure 1). The Marathon House is also referred to as Phoenix House in some documentation. This study area is 522 acres. A WHPA delineates the land area where rainfall is expected to recharge groundwater and where groundwater flows toward a pumping well. Generally this area receives a higher level of protection through zoning ordinances since activities occurring in this area may affect drinking water. A non-community well may be either a non-transient non-community or a transient non-community well. A non-transient non-community well serves at least 25 of the same persons who are not residents over 6 months of the year. This would include uses such as schools and places of employment. A transient non-community well does not regularly serve the same persons but does serve at least 25 people for at least 60 days of the year. This category would include uses such as restaurants and motels. All the WHPA data used in this study was updated RIDEM Draft 2005 data that has yet to be promulgated.

Figure 1: Study Areas

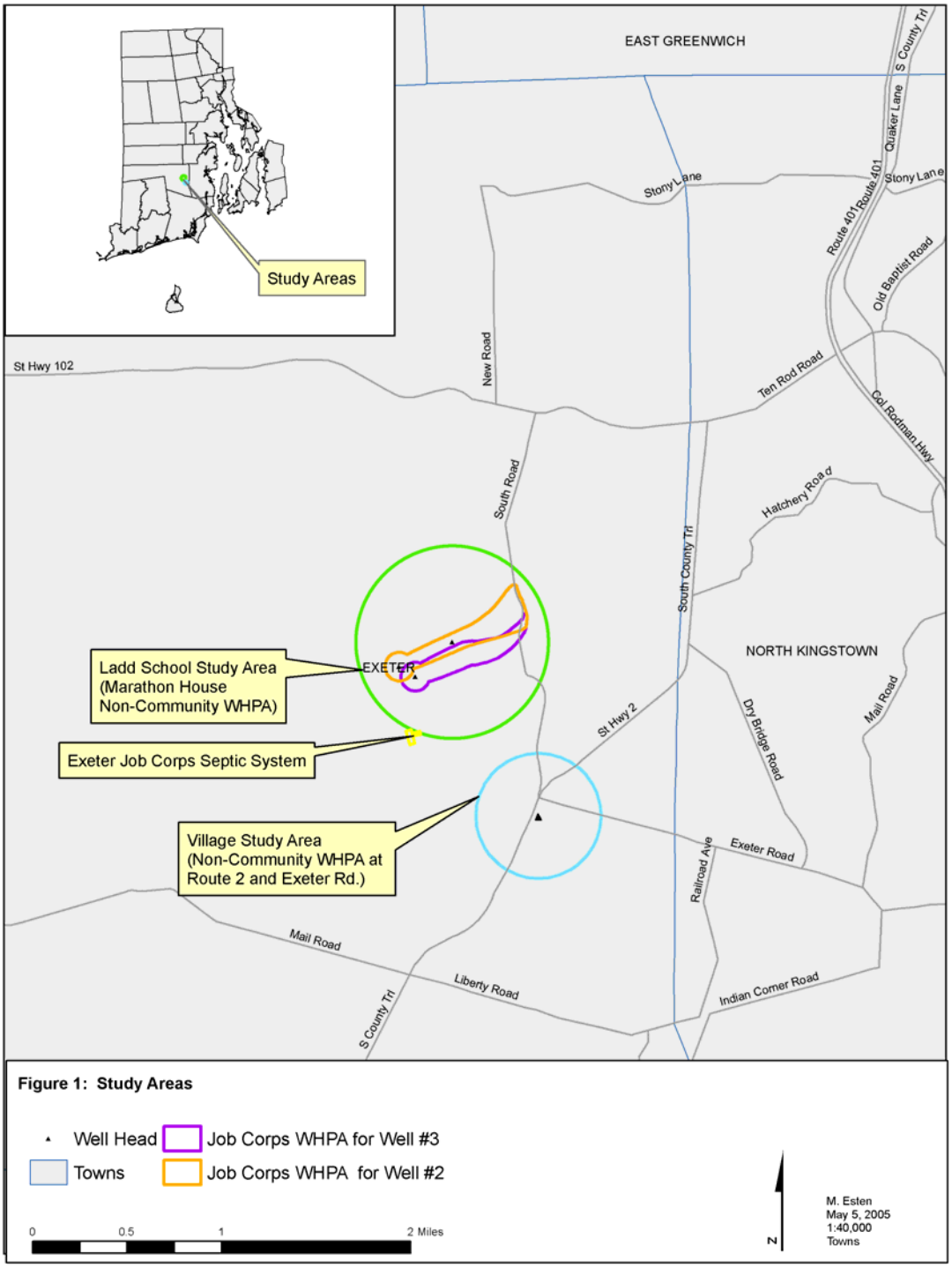
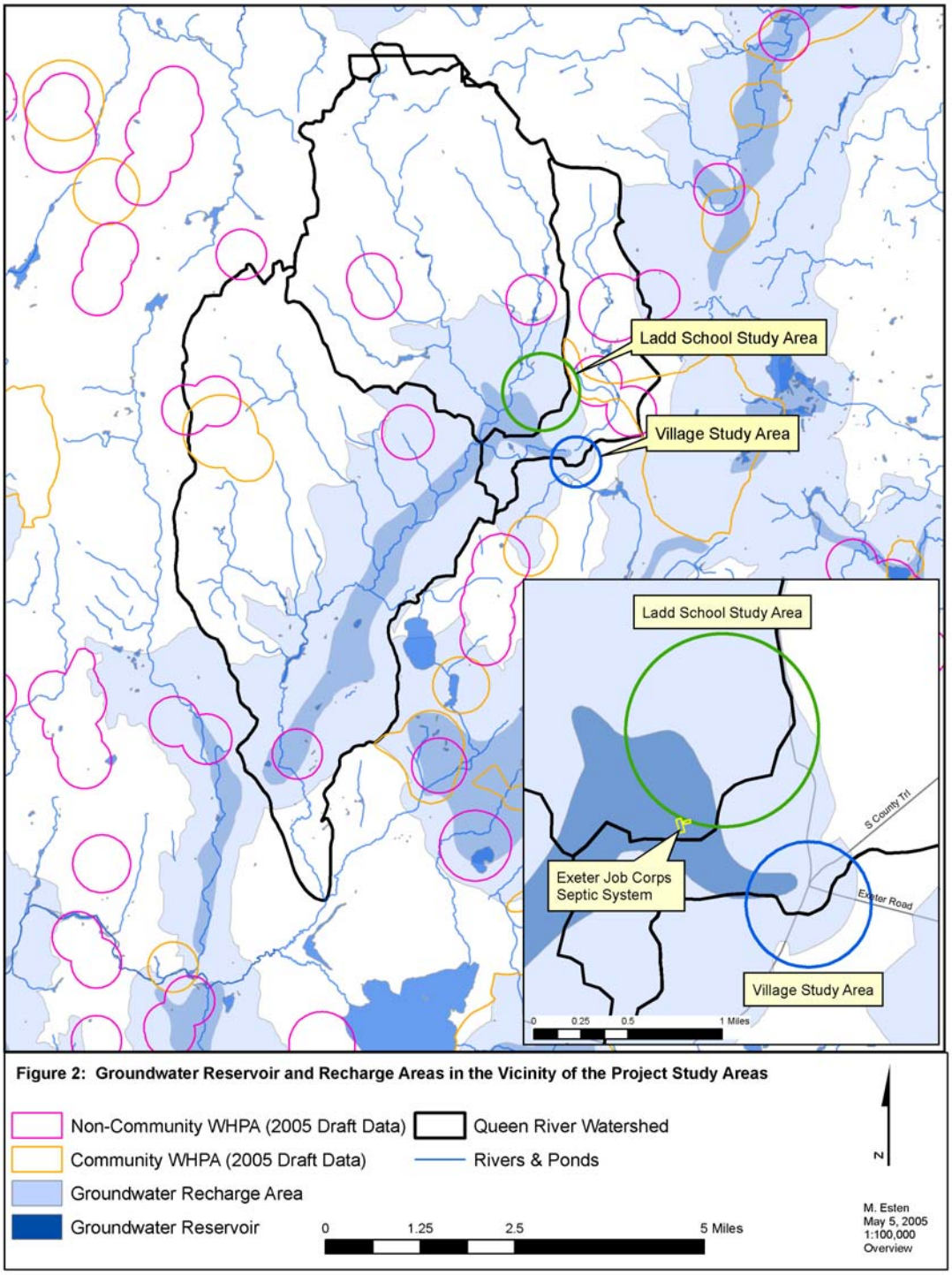


Figure 2. Groundwater Reservoir and Recharge Areas in the Vicinity of the Project Study Area



The Marathon House WHPA encompasses the two wellhead protection areas delineated for the former Ladd School wells. Historically the Ladd School had three operational wells. Currently, only two of the three wells are in operation. These wells are referred to as the Rhode Island Community Living and Support wells or the Job Corp Wells, as they appear to be servicing the Federal Job Corps Center that was built on part of the former Ladd School property some time after 2001 as well as a fire fighters training facility also located on the site. The Job Corps Center is a technical training center that is comprised of teaching and dormitory space. The septic system serving the center utilizes an innovative /alternative septic system design to decrease nitrate loads to groundwater. Although this septic system it is located just outside the Ladd School Study Area it was assumed to be in the study area for purposes of the MANAGE analysis (Figure 1). This is based on the uncertainty associated with delineation on the WHPA, which was developed using a groundwater flow model based only on limited hydrogeologic data. The wellhead protection area boundary is an estimate, where the actual shape and extent of the boundary is likely to be either greater or smaller. The delineations are based on reasonably available information regarding the hydrogeologic environment and well characteristics, including pumping rates. The WHPA methodology differs depending if the well is drilled in stratified drift (sand and gravel deposits). The WHPA for a stratified drift well is a curve generated by an analytical model. This accounts for the elongated shape of the Job Corps wellhead protection areas. The WHPA for bedrock well is a circle with the radius dependent on the well's pump rate and type of water supply, as indicated by the Phoenix House WHPA and the WHPA serving the Post Office and businesses in the so-called Village Study Area, as shown in Figure 1. Because wellhead delineations are based partly on well pumping rates, increased water withdrawal may expand the outer limits of the wellhead area and increase the potential for effluent movement towards the pumping wells.

The Ladd School Study Area is located entirely in the upper reaches of the Queens River, a major tributary of the Pawcatuck River system, which eventually discharges to Little Narragansett Bay at the mouth of the Pawcatuck River estuary in Westerly. The study area also includes both groundwater aquifer and groundwater reservoir areas (Figure 2) associated with the Queens River. A groundwater aquifer is a subsurface formation capable of providing a water supply. In this case, the aquifer is composed of deep sand and gravel deposits where groundwater is stored in the spaces between the grains of sand. This type of aquifer can provide very high water yields but because there is no protective layer separating the infiltrating water from underlying sand and gravel deposits, this "unconfined" aquifer is also considered highly vulnerable to contamination. The aquifer is recharged from rainfall directly over the sand and gravel aquifer and from infiltrating runoff from adjacent areas. Groundwater aquifers are delineated by RIDEM to include the critical portion of the recharge areas and groundwater reservoirs. The groundwater reservoir is the portion of the aquifer estimated to have the deepest sand and gravel deposits, and where potential yield for public wells is likely to be the greatest. Under the RIDEM Groundwater Protection Program the groundwater reservoir are "stratified drift deposits having a saturated thickness greater than or equal to 40 feet and a transmissivity greater than or equal to 4000 feet squared per day which have been designated potentially significant sources of water." Like the wellhead protection areas, the location of the groundwater reservoir is approximate, drawn based on limited data. The actual boundary is likely to vary. While it is possible to obtain groundwater from areas outside of the recharge or reservoir area, these areas are extremely valuable as likely sources of significant yields for or current and future supply.

2.2 Village Study Area

The Village Study Area is the non-community WHPA associated with the intersection of Route 2 and Exeter Road, covering 220 acres (Figure 1). This area encompasses a post office and small commercial development. It is being considered as a hypothetical site for further development. The study area is located partially in the Queen River watershed and partially in the upper reaches of the Slocum River watershed as well as in groundwater recharge and reservoir areas (Figure 2). The Slocum River watershed appears to drain to a lake known as The Reservoir and

then to Yawgoog Mill Pond. This flows to Hundred Acre Pond and then forms the Chipuxet River, which flows to Wordens Pond and like the Queens River, eventually joins the Pawcatuck River and discharges to the Pawcatuck Estuary.

2.3 Project Setting

Evaluating natural features of the study area within the context of the larger watershed or groundwater recharge area is a very basic but important aspect of the analysis. Although it is beyond the scope of this project to summarize existing conditions, this section briefly describes the relationship of the Study areas to the larger Queens River watershed and groundwater resources, wetlands, and protected lands.

2.3.1 The Queens River

According to the Nature Conservancy, "The Queen's River is considered one of the most pristine rivers in the state. Its watershed encompasses 23,000 acres of forest, field, wetland, and river. Because of the relatively unimpacted nature of the river, it contains a number of rare elements that depend upon clean, cold, running water." (TNC 2005). The river system is home to native trout, rare and endangered dragonflies, and stoneflies. Studies indicate a great diversity of aquatic invertebrates, including freshwater mussels, mayflies, and stoneflies.

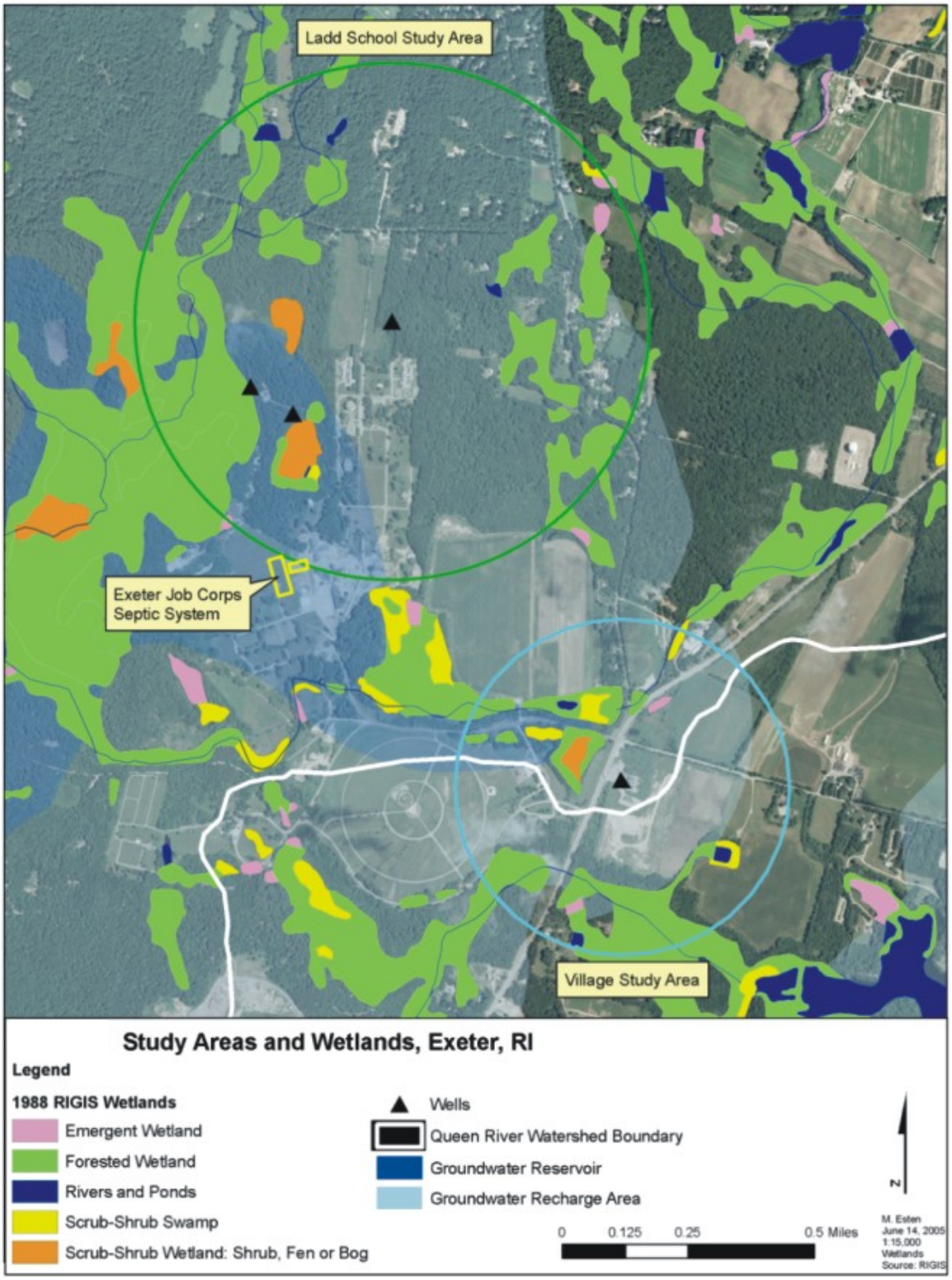
Because of the great value of the Queens River in its unimpaired state, The Nature Conservancy and the Rhode Island Audubon society have made acquisition of land and land easements in this watershed a top priority in the State and region. According to Rhode Island Audubon, the Marion Eppley Wildlife Refuge, located south of the Ladd School site, is "one of the largest of the 15 refuges owned by Audubon, not including additional land protected by easements. Because of its pristine condition and habitat sensitive to human disturbance, this is the only RI Audubon refuge not open to the public, but is maintained as an unspoiled and unbroken tract for wildlife habitat and study".

Collectively, the purchase of land and easements in the Queens River watershed by The Nature Conservancy, RI Audubon, and private landowners, with support by the Rhode Island Department of Environmental Management, represents a significant investment of public and private funds. Because of the value of groundwater resources for water supply, state and federal funds have been invested in studies of water supply capacity, including assessment of streamflow requirements specifically for habitat protection conducted by the U.S. Geological Survey (Armstrong and Parker, 2002).

2.3.2 Wetlands

Wetlands in the vicinity of the project sites are shown in Figure 3. Here the Queens River watershed boundary is shown in white. Land north and west of this boundary drains to the Queens River and associated wetlands, while land south of this watershed boundary will eventually drain to the Chipuxet River. Based on RI Geographic Information System (RIGIS) mapping, forested wetlands, shown in green include red maple swamps and are by far the most commonly occurring wetland type. Bogs and fens, mapped in orange, are relatively uncommon, comprising only 0.002% of all wetlands in Rhode Island (Nichols and Miller, 2000). Bogs and fens are highly valued because of they are unique and irreplaceable habitats, and they support equally unique plant life such as Pitcher plants *(Sarracenia purpurea)* and sundews *(Drosera)*.

Figure 3: Study Areas and Wetlands



These plants are carnivorous and are able to trap and digest insects to obtain necessary minerals missing from the soil. In addition, bogs typically have very low nutrient levels, and are considered highly susceptible to hydrologic changes and increased nutrients. As shown in Figure 3, there are three bogs located in the study areas, including a large bog in relatively close proximity to the Ladd school complex.

2.3.3 Groundwater Resources and Protected Land

The groundwater aquifers located in Exeter are part of the EPA-designated Wood-Pawcatuck "sole source" aquifer. This designation is reserved for groundwater resources that provide the only source of drinking water supply, without alternatives available. EPA recommends the highest level of protection for these areas. As noted in section 2.1, the groundwater recharge area (Figure 2, shown in light blue) is the area capable of storing and transmitting large quantities of water stored among subsurface sand and gravel deposits The smaller groundwater reservoir within the large aquifer (Figure 2, shown in dark blue) is the area of deepest sand and gravel deposits and highest rate of groundwater flow through coarse sand and gravel, capable of reliably supporting high-yield wells. The groundwater reservoir is therefore the most valuable resource for future public water supply wells.

To determine the extent of the available groundwater recharge area available for water supply, and to evaluate whether expansion might further infringe on these resources, we mapped groundwater resources relative to current development. The groundwater aquifer and the groundwater reservoir with potential for higher yield are shown overlaid on the aerial photograph (orthophoto) in Figure 4, Study Areas and Groundwater Resource Areas. It is important to note that the groundwater resource features are best estimates modeled based on limited field data. Actual boundaries between the groundwater recharge area and the deeper sand and gravel reservoir are not distinct and the may be larger or smaller. This map shows that the Job Corps onsite wastewater treatment system, much of the development associated with the Ladd School and portions of the Veterans Memorial Cemetery are located within groundwater reservoir. The Village study wellhead area is located on the eastern edge of the groundwater reservoir, outside of the groundwater reservoir.

Under RI HEALTH regulations, the area within 400 ft of public gravel wells must be protected from potential source of pollution. RIDEM also requires a minimum 400 ft setback from an onsite system to a public well. This 400 ft buffer, known as the inner protected radius, creates a circle with an area of at least 11.5 acres where new development is restricted. In critical areas such as the Coastal Ponds and Scituate Reservoir watershed, RI DEM Individual Sewage Disposal System (ISDS) minimum standards (RIDEM, 2002) require 3 times the standard setback from a large system (> 2000 gpd), for a total distance of 1200 feet (Section S.D. 3.05). This results in a protected area of 104 acres where new water supplies would be at high risk of contamination. Because the Job Corp wastewater system is located in the center of the mapped groundwater reservoir, the buffer area created by either a 400 ft or 1200 ft setback would overlay the groundwater reservoir, eliminating this area from future water supply production.

In addition to developed land and associated setbacks, it is assumed that protected land acquired for conservation purposes would be unavailable for siting new wells. Figure 5, Groundwater Resources and Protected Land, illustrates groundwater resources and protected land under the control of State, town, non-profit and private groups townwide. The groundwater reservoir west of Rt. 95 is entirely included within State management lands. The Queens River groundwater reservoir is also under protection, except for the current study areas. This leaves the groundwater

reservoir associated with the Chipuxet River not protected, however DEM has designated segments of this river system are impaired due at least in part to low flow conditions associated with water withdrawals. As a result, siting new public wells in this area may be undesirable, especially in upper watersheds with small 1st and 2nd order streams that are most susceptible to drawdown impacts.

A closer view of the groundwater resources in the study area relative to protected land is shown in Figure 4, Study Areas and Protected Land. When considering land already developed at the Ladd School site, the Veterans Cemetery, and Job Corps septic system with buffers, the amount of available reservoir area suitable for high-yield wells is very limited and therefore very valuable.

Note: For relative size comparison, the distance from the Job Corps onsite system to the Job Corps wells is slightly greater 1200 feet and the Village study wellhead area has a radius of 1750 ft, covering 220 acres.

Figure 4 Study Areas and Groundwater Resources

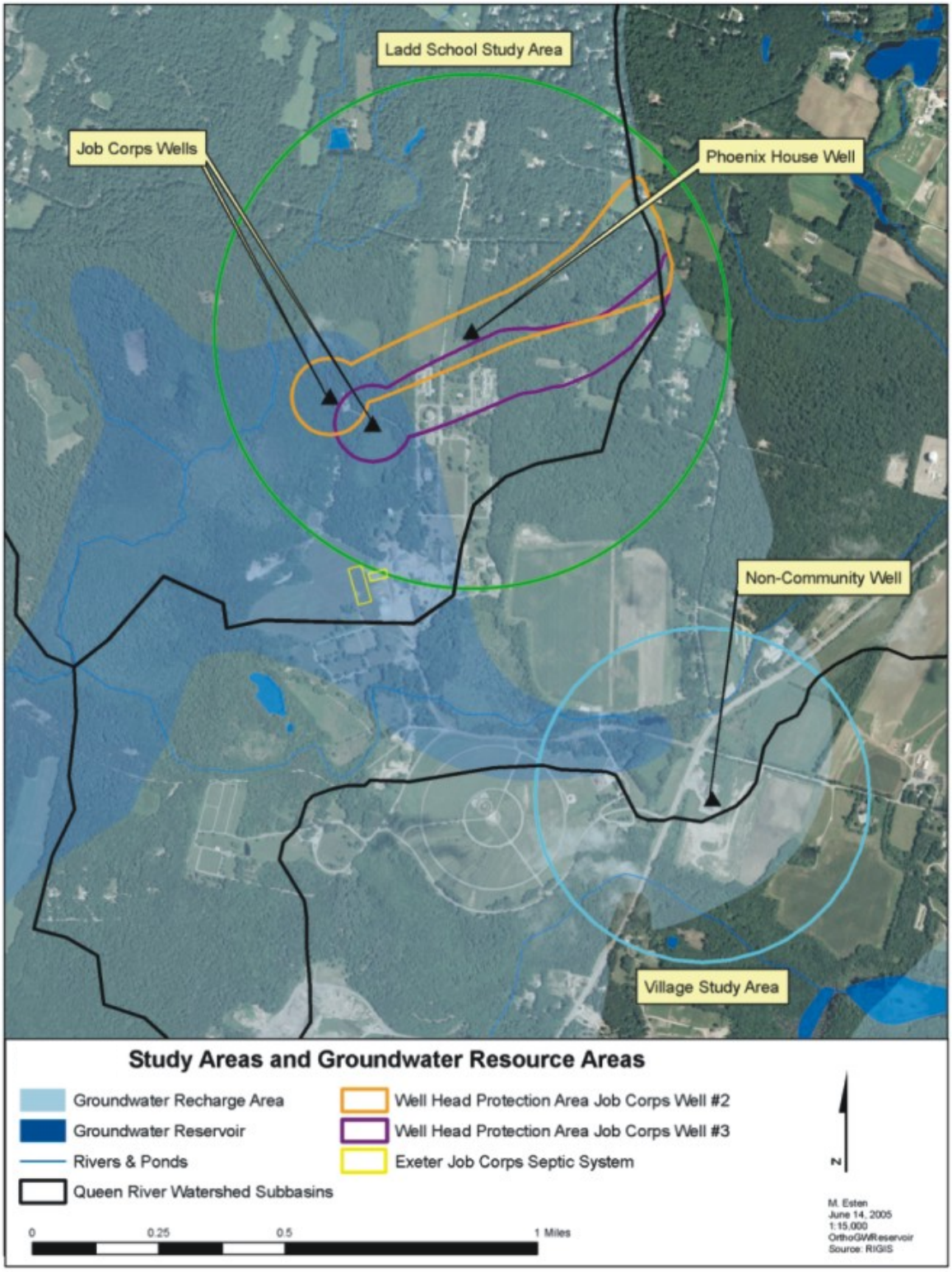


Figure 5. Groundwater Resource and Protected Land

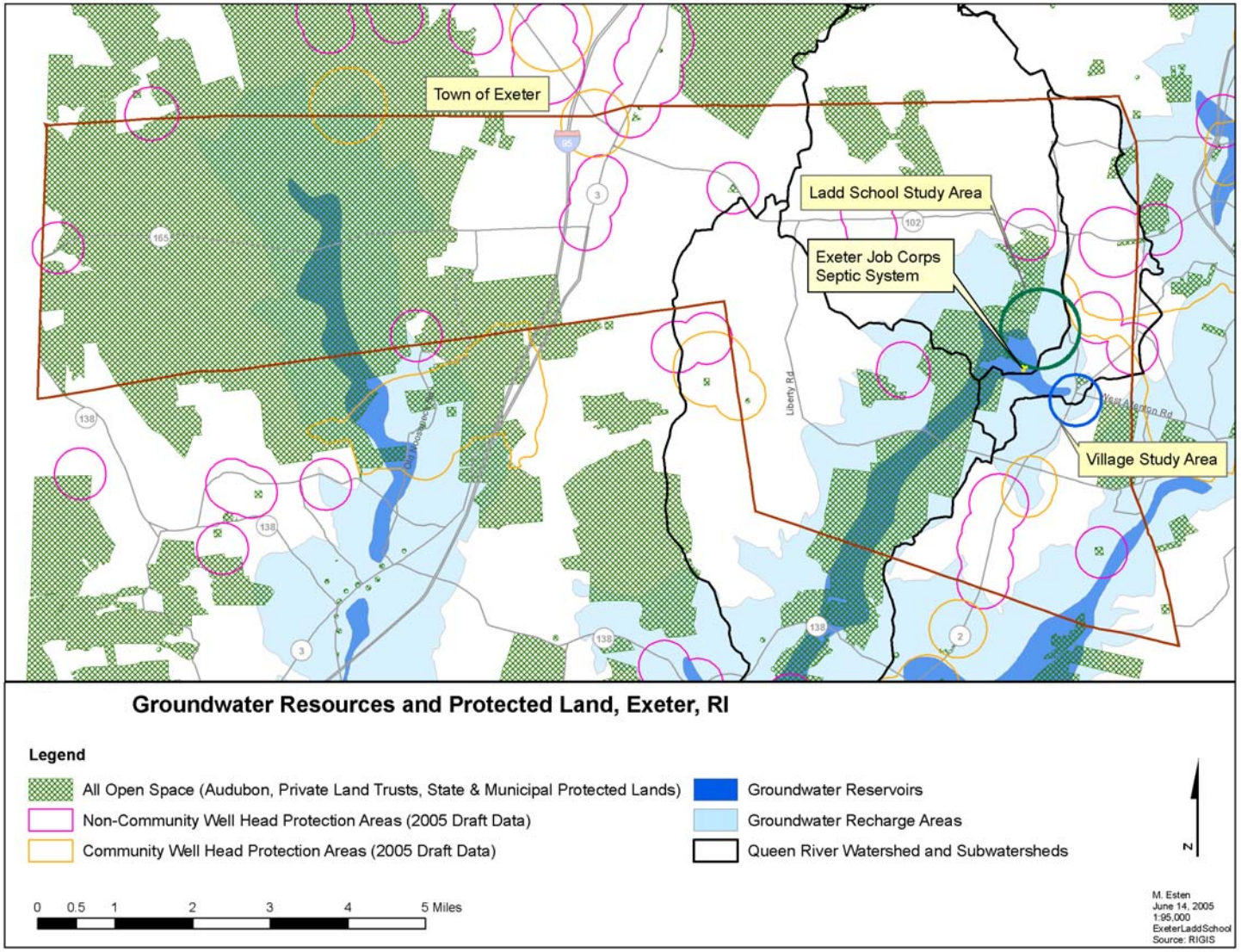
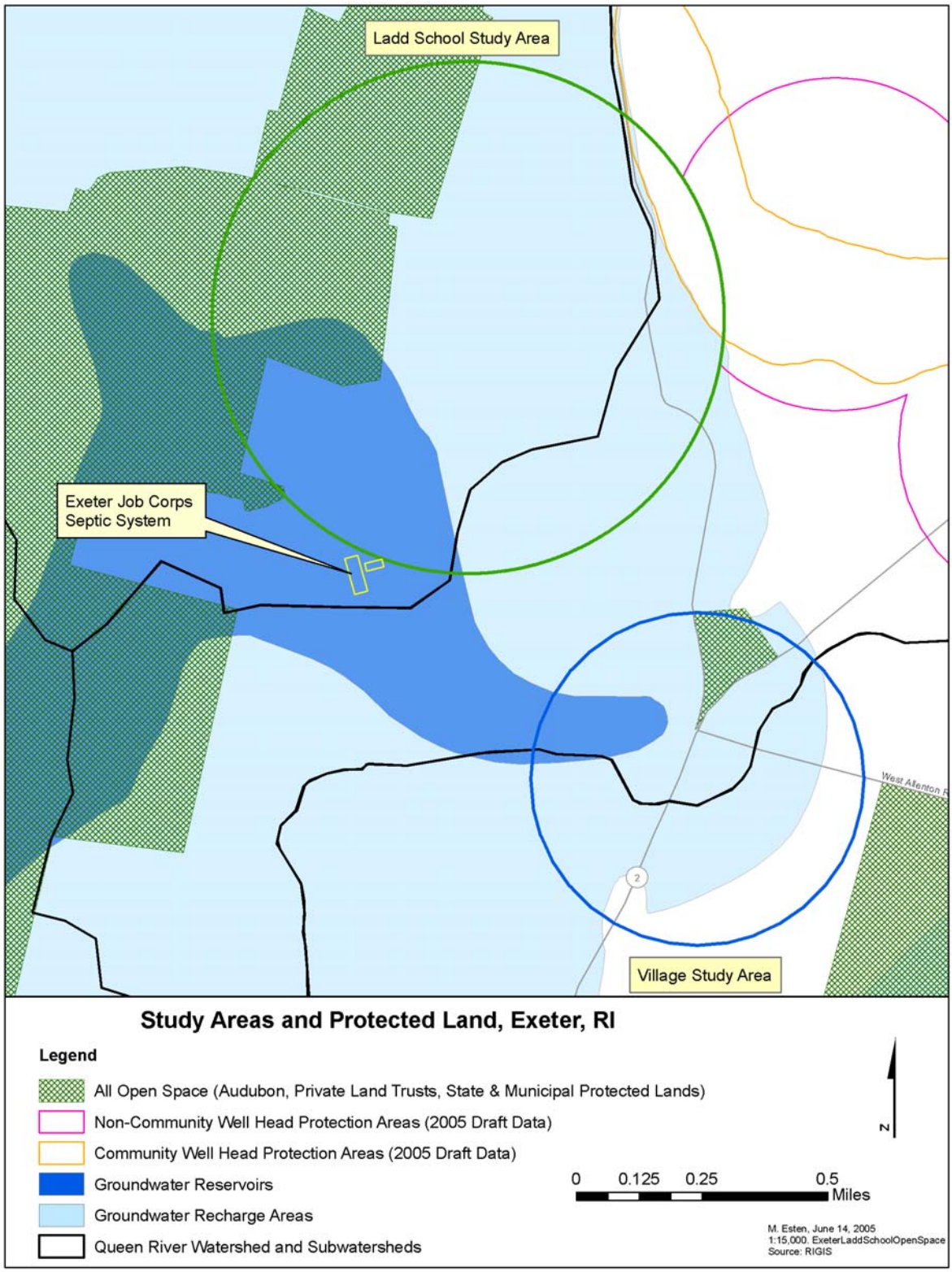


Figure 6. Study Areas and Protected Land



3.0 MANAGE POLLUTION RISK ASSESSMENT

3.1 Data Collection

Data collection consisted of a two-part effort: 1) collecting and reviewing existing reports on potential impacts of development at the Ladd School site; and 2) compiling a geographic database to understand and display current site conditions in both study areas. These data included available GIS data from the Rhode Island Geographic Information System (RIGIS) system for: land use, soils, water bodies (rivers and ponds) and any existing sewer lines, as listed in Table 1. Land use in the study areas was field verified and updated based on current land use type. Much of the current land use type in both study areas is forest, brushland or wetland (Figure 7).

For the modeling analysis, an ArcInfo command file was used to compile soil and land use information for the study areas into a format needed to input into the MANAGE spreadsheet. This operation was performed by Paul Jordan, GIS specialist for the RI DEM, in the interest of supporting local resource-based land use management decisions, and to assist our office in adapting the model to the more recent Arc GIS version 9. The MANAGE model runs in an Excel spreadsheet and incorporates the widely-used mass balance model concept. A mass balance uses a simplified water and nutrient budget to establish a quantitative relationship between pollutant inputs and outputs to a system. The nutrient loading component of MANAGE estimates pollutant outputs as nutrients (nitrogen and phosphorus) entering surface water runoff or infiltrating as recharge to groundwater. Phosphorus is used as an indicator of sediment-bound pollutants in runoff. Nitrogen is used as an indicator of other dissolved pollutants in surface runoff and in recharge entering groundwater. Map analysis to locate and display potential pollution threats is an additional and very important element in this analysis.

The assumptions used in the MANAGE model are found in the Appendices. Appendix A includes wastewater loading assumptions for the development scenarios; Appendix B provides modeling results with detailed assumptions for each analysis; Appendix C provides technical documentation of the MANAGE model, and Appendix D provides documentation on pollution risk indicators and their ranking. Data generated by the model is considered useful as a planning tool, as data obtained from any model should be considered an estimate of future conditions given that the complexity of the natural environment does not allow for absolute answers. Additionally, a model is only as reliable as it assumptions. If the assumptions within the model are not appropriate for a given area then the results will not be correct. The real power of the MANAGE approach is to evaluate the relative change in pollution risk factors for the study area with changing land use and with use of pollution control practices. In addition, mapping resource features relative to high risk land uses is an important aspect of the evaluation.

The hydrologic component of the model assumes that the average annual precipitation in the study areas is 45 inches per year, with 18 inches per year lost to evapotranspiration, or evaporation and plant use. The proportion of the remaining “available” precipitation that is converted to runoff is estimated using runoff coefficients based on the estimated impervious cover for each land use type and the underlying soil hydrologic group. The remainder is assumed to seep into the ground to recharge either shallow or deep groundwater. Recharge to groundwater from septic systems is calculated separately based on average per capita wastewater discharge of 50 gallons per person per year.

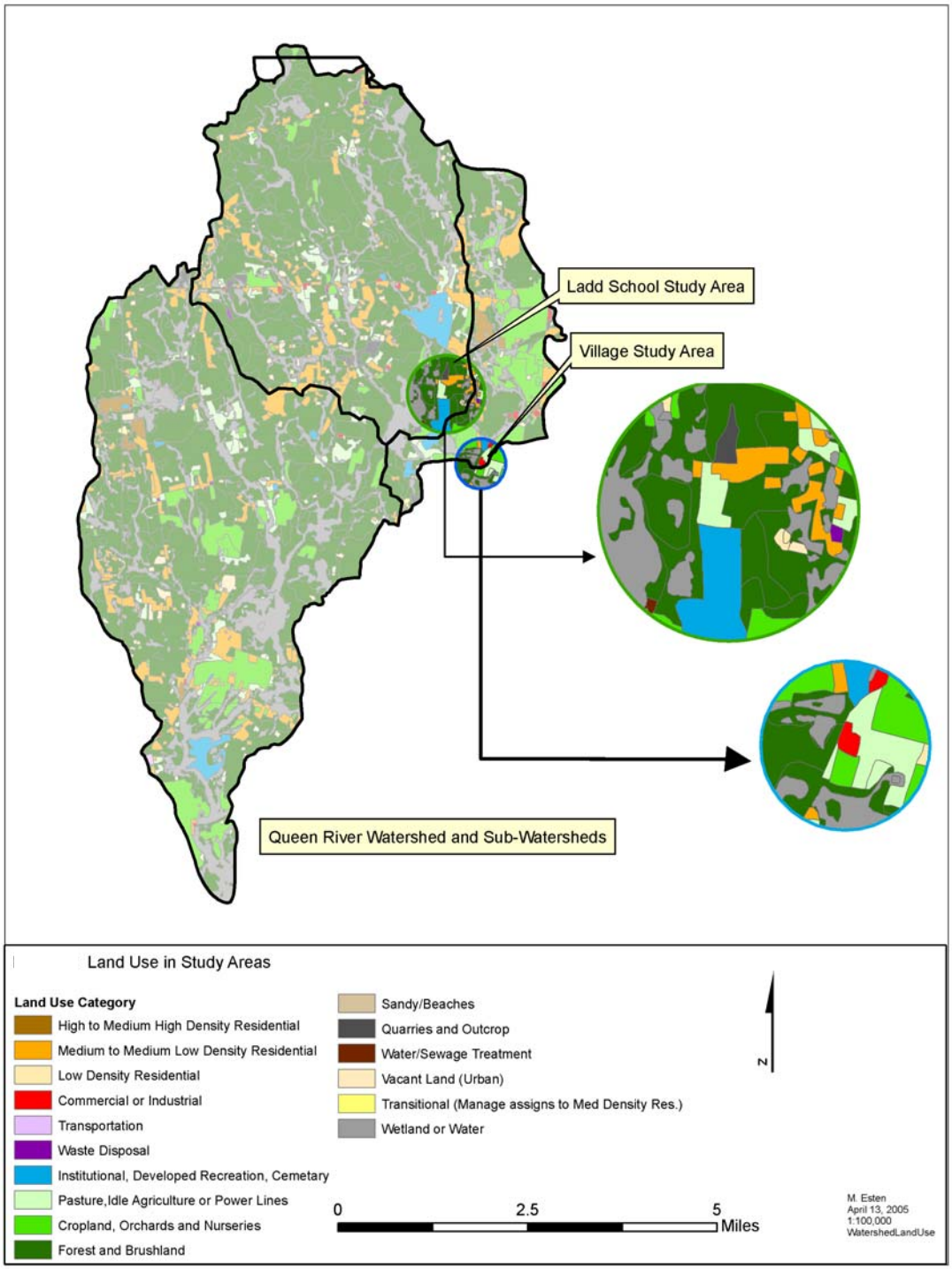
Nitrogen and phosphorus inputs to surface water from stormwater runoff are estimated using generalized pollutant coefficients based on published literature values for 21 different land uses and direct atmospheric deposition on surface waters. Nitrate-nitrogen inputs to groundwater recharge are calculated separately, using results of URI field research on nitrogen losses to groundwater from specific sources, including septic systems, lawns, farmland and forest.

It is important to note that nutrient loading estimates represent sources, with nitrogen and phosphorus estimated at the point where runoff is generated. Nitrate-N entering groundwater recharge is estimated as the amount entering groundwater recharge. For both runoff and groundwater recharge inputs, no attempt is made to account for natural losses that may occur before pollutants reach surface waters or groundwater at the depth of a well intake. That said, the quality of a groundwater recharge area is likely to eventually reflect the quality of infiltrating recharge.

Table 1 Geographic Information System Data Sources

GIS Data Layer	Source
Well Head Protection Areas (WHPA)	RIDEM office of Groundwater Protection and RIGIS. The WHPAs for the EDC Job Corps wells are updated delineations not yet available in RIGIS. The larger Phoenix House WHPA and all other WHPAs were available from RIGIS.
Job Corps ISDS	Visually determined the location of ISDS using orthophotographs
Non-Community and Community WHPA	RIGIS – 2005 data
Groundwater Recharge and Reservoirs	RIGIS
Roads, watersheds, ponds and rivers	RIGIS
Wetlands	RIGIS – 1988 data
Orthophotographs	RIGIS – 2003 USDA-FSA National Agriculture Imagery Program (NAIP), 1m color orthophotographs, 1:12,000 true color orthophotographs
Open space	RIGIS – Join of data containing private land trusts, state and municipal protected lands and Audubon holdings
Land Use	RIGIS – 1995 land use
Soils	RIGIS

Figure 7. Land Use in Study Areas



3.2 Overview of Alternative Development Scenarios

Future development scenarios for the Ladd School area and the Village area were developed in cooperation with the Exeter Economic Development Committee. These represent hypothetical development options based on current land use, proposed development and existing plans for the intensity of development.

Ladd School Site

Under the Ladd School alternatives, future development would be concentrated in the area of approximately 50 acres currently mapped as institutional land use, as shown in the cross-hatched area in Figure 8. This shows the existing Job Corps septic system and a hypothetical area for siting a 45,000 gpd system to accommodate future development. It is important to note that this is a general location for wastewater treatment based only on suitable soils with few buildings. This site may be unsuitable due to proximity to wells and location within wellhead protection areas, however, proposed locations of building sites and onsite systems were not readily available. The same area is shown in Figure 9, using soils rather than existing land use to identify potentially suitable areas.

Village Study Area

The Village scenarios, also shown in Figures 8 and 9, were developed to explore the potential suitability of this site as an alternative to more intense development of the Ladd School site. This general location was evaluated as a site for a new village growth center by students of the URI Landscape Design studio class, under the direction of Dr. Will Green.

Directing new growth to the Village site from Ladd School has been proposed because it offers the following opportunities:

- Provides the opportunity to create a new growth center for growth with direct highway access and visibility, that could attract both commercial investment and meet residential housing needs, including for example, elderly and low-income housing.

- With public water provided by nearby Ladd area wells, can support compact development, efficiently designed within a small area while preserving surrounding open space in keeping with Exeter's rural character.

- Removes new development from the Queens River reservoir, thereby protecting one of the few available areas for high-yield wells to meet future water supply needs.

- Large-flow pre-fabricated wastewater treatment technologies are available for new development at either the Ladd or Village area, that provide a very high quality effluent, specifically designed for removal of phosphorus, nitrogen and bacteria. The treated effluent can be re-used for flushing and landscape irrigation, thereby reducing total water use.

- Highly treated wastewater can be dispersed to leachfields sited on the outer edges of the Queens River aquifer, maintaining groundwater recharge while also providing longer distance and travel time for additional treatment through natural processes before reaching the groundwater reservoir, wells or the Queens River.

- New development, and treated stormwater and wastewater discharges could be sited within the Chipuxet River watershed, where aquatic habitat is considered less sensitive to human impacts.

The Village scenarios shown in Figures 8 and 9, depict strictly hypothetical development locations since new construction could be sited entirely outside the existing wellhead area or outside the Queens River watershed (the watershed boundary is not shown in these figures). In addition, if public water from the Ladd area was brought in and all existing and future uses connected, the wellhead protection area would be eliminated, since these exist only for active wells. The Village scenario on the left shows the low intensity option where 50 acres are converted to commercial use. This is comparable in area and wastewater flow to the current Ladd School development. The future high intensity option is shown on the right, whereby an additional 50 acres is developed, and total wastewater flow is comparable to the intensive future use of the Ladd school area. Because the general location of the Village development, onsite wastewater treatment systems, and type of water source were all highly uncertain, the risk assessment was conducted using a worst-case scenario where all new development and onsite systems are located within the existing wellhead protection area. A description of the various scenarios evaluated using the MANAGE assessment follows.

3.2.1 The Ladd School Study Area MANAGE Analysis

Three MANAGE scenarios were analyzed for the Ladd School study area, as described below and summarized in Table 1.

1. Ladd 1 Current land use. The first scenario represents the current conditions in the Ladd School Wellhead Protection Area (WHPA), including the current Exeter Job Corps onsite wastewater treatment system (recirculating sand filter with pressurized shallow drain field), also known as an Innovative /Alternative (I/A) Individual Sewage Disposal System (ISDS). This assumes that all land management remains the same, without new construction on the institutional land (shown in Figure 8), and with no disturbance of existing fields, forest or wetland buffers.

2. Ladd 2 Future land use. The second analysis is an estimation of future conditions at the site by assuming that all 54 acres of institutional land in the study area are converted to commercial land, resulting in more intensive use of the site. There would be no disturbance outside this area and all other land use would remain the same. A new wastewater treatment system would be constructed to serve an additional 3000 persons per day, using a denitrifying technology capable of removing 50% total nitrogen. This shift from institutional land use to commercial land use changes the input assumptions as follows:

- An increase in impervious surface from 34% for institutional land use to 72% for commercial land use,
- An increase in surface runoff and total nitrogen surface water export coefficients,
- A minimal increase in the total phosphorus surface water export coefficients and
- A slight modification of the nitrogen load to groundwater (Appendix C).

3. Ladd 3 Future –Reduced Runoff. The third analysis for the Ladd School study area included the same assumptions as the original future scenario (Scenario Ladd 2) as well as a reduction in impervious surface associated with commercial development from 72% to 40% and a slight reduction in the runoff coefficient from commercial to high density residential development. Changing the runoff coefficient to high density residential allows the model to mimic runoff at a lower impervious level, as changing the percentage of impervious surface does not directly affect the runoff volume in the model. This final scenario models potential site conditions if low impact development principles (reduction of impervious surface) are used when constructing commercial development on the site. The runoff volume and nutrient loading estimates are designed to calculate average annual values based on the runoff likely to be generated, without taking into account temporary storage, settling or infiltration before reaching a water body. It does not take into account effect of stormwater management/treatment techniques.

Figure 8. Areas of Potential Development

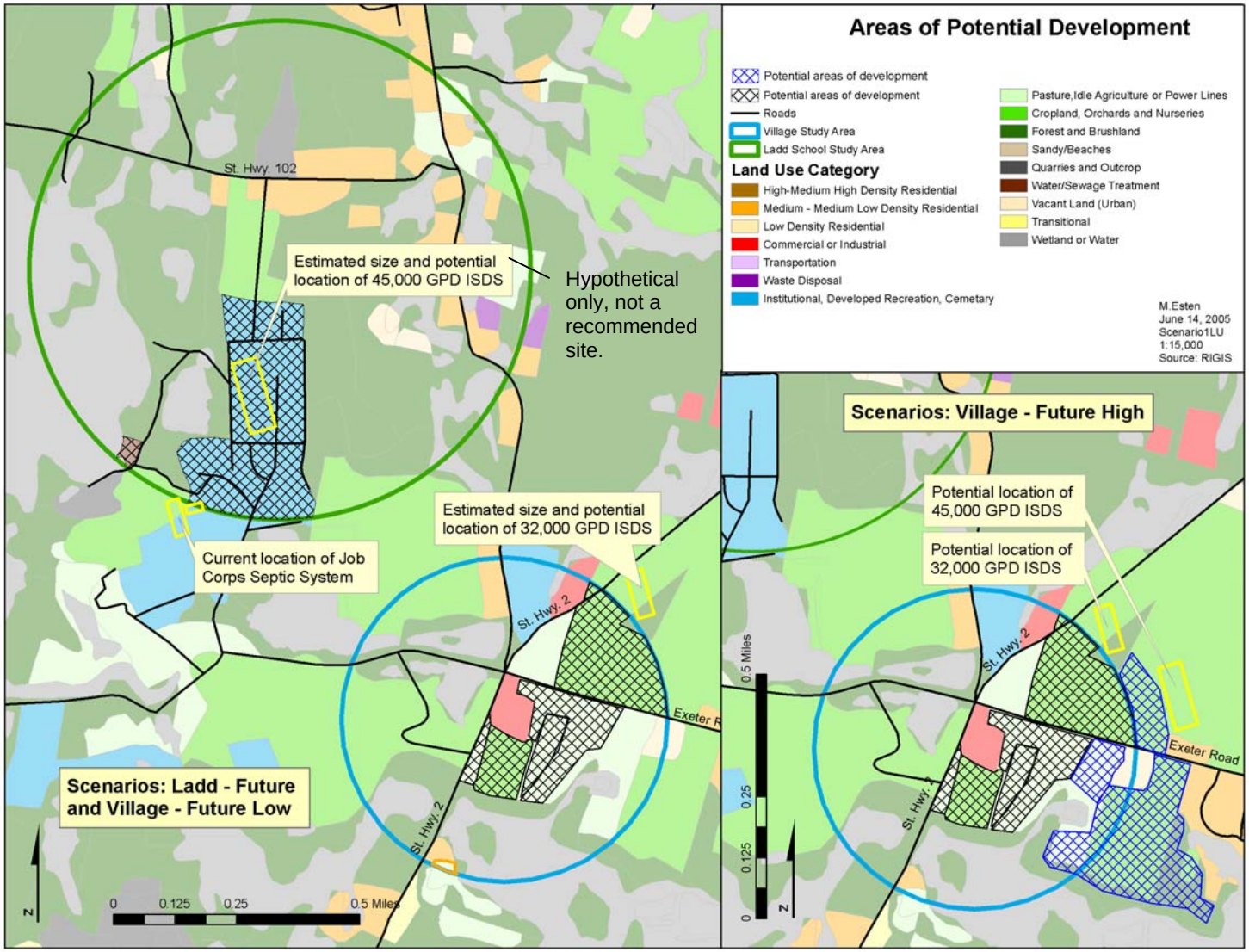
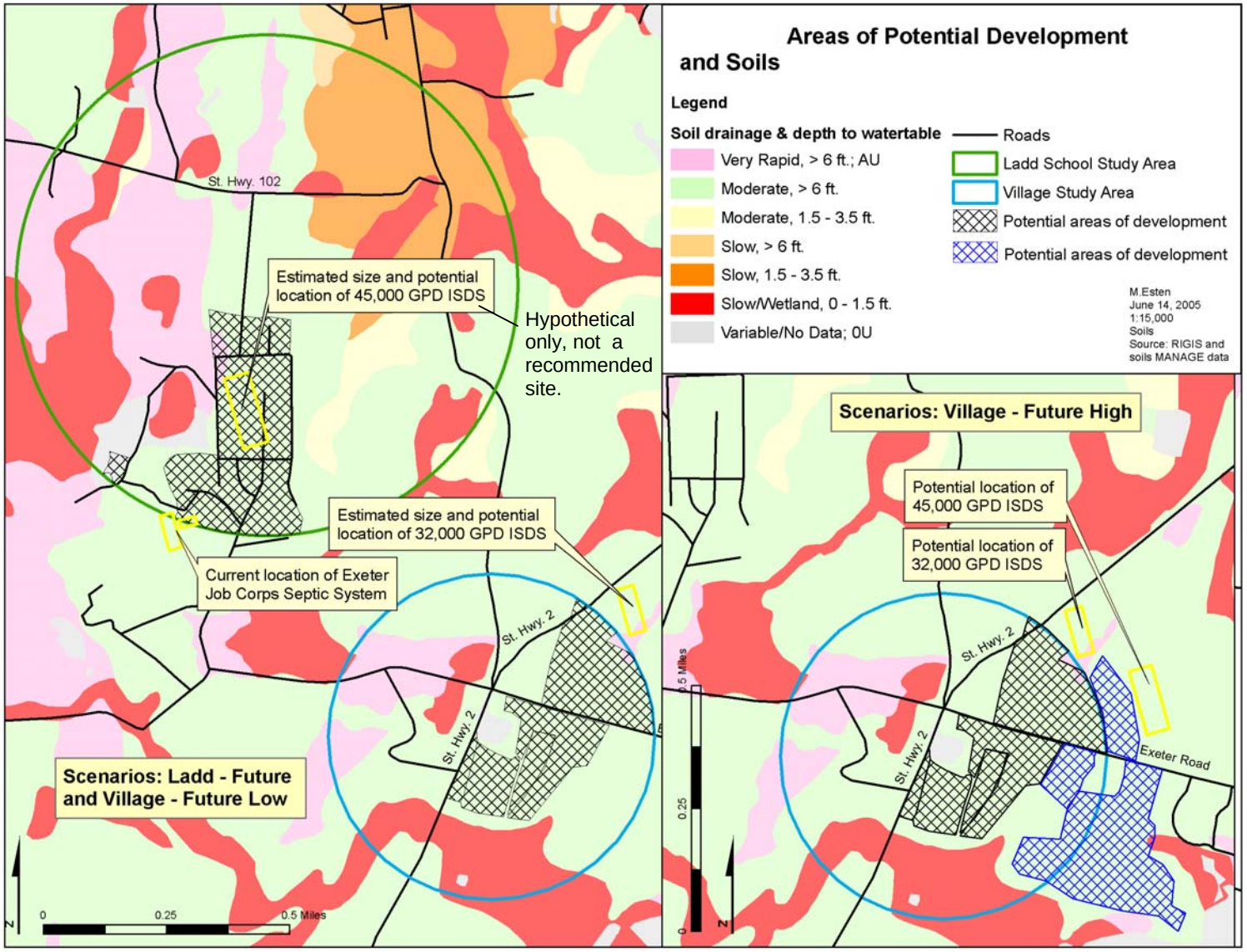


Figure 9. Areas of Potential Development and Soils



3.2.2 The Village Study Area MANAGE Analysis

The Village Study area offers a possible alternative development site outside of the town's primary groundwater reservoir and further removed from the highly sensitive Queens River conservation area. This site, the subject of village center design project by URI Landscape Design students, was selected by members of the Exeter Economic Development Committee for further study. Hypothetical development conditions to support development here may include extending public water from the Ladd school site, thereby eliminating development constraints within the existing wellhead protection. In addition, onsite wastewater treatment system(s) could be sited either outside of the Queens River watershed or just within outer edges of the groundwater aquifer to maintain recharge while also providing much greater setbacks and travel time to reduce pollutant movement through natural processes. However, given that extending public water from the Ladd School area is not assured, potential pollution risks were modeled assuming all development would occur within the existing wellhead protection area.

Six scenarios were analyzed for the Village study area. These are described in greater detail, with estimated wastewater flows and assessment results in Appendix A and B. The first scenario (Scenario Village 1) represents current conditions. The second scenario (Scenario Village 2) represents a future low development scenario where 50 acres of agricultural land (cropland, pasture, brush) are converted to commercial development. The low development scenario assumes that 457 additional persons will be discharging waste through ISDS's into the project area. All future scenarios assume that newly constructed ISDS will be of I/A design. The third scenario (Scenario Village 3) represents future conditions if 100 acres of agricultural land are converted to commercial land uses and an additional 1014 persons will be discharging effluent to the project study area. Scenarios 4 through 6 are modifications of the Village Future High scenario (Scenario Village 3). All the assumptions that were made for Scenario Village 3 are also included in these scenarios. Scenario Village 4 is similar to that of Scenario Ladd 3, the impervious surface associated with commercial development was decreased to 40% and the runoff coefficient adjusted to high density residential. Scenario Village 5 represents a reduction in impervious surface associated with commercial development to 25%. The final scenario for the Village study area (Scenario Village 6) represents no net increase in surface runoff and complete treatment of all stormwater runoff generated on-site. The impervious surface for commercial development was decreased to 25% and the runoff coefficients and surface nutrient loading coefficients were reduced from commercial to brush in this final scenario. This scenario may represent an unattainable goal.

Because the Village scenarios were modeled assuming all development and wastewater discharges would be sited within the existing wellhead protection area, these estimates provide a worse-case scenario of potential impacts. The future scenarios for the both the Ladd School and Village study areas use comparable wastewater design flows so that the use intensity is similar. However, there are important differences between the two sites such that results cannot be compared directly, for example: the Ladd School WHPA is almost twice as large as the Village WHPA, providing a much larger area for dilution. As a result, even though the total amount, or loading of pollutants is the same from both areas, nutrient inputs will be much less for the larger Ladd area when presented as pounds per acre or as a concentration (mg/l) diluted with rainwater infiltrating the area.

3.2.3 Assumptions regarding current and future ISDS numbers in the study area.

The MANAGE method calculates the number of ISDS in an area using assumptions about the number of septic systems per acre likely to be associated with each RIGIS land use category.

Each land use type is assigned a number of ISDS units per acre and this value is multiplied by the acreage of each land use type to determine the total number of ISDS. The low end of each residential density category is used based on previous comparisons with census and parcel data. This value was used in the MANAGE models in this study for current medium density, medium low density and low density residential and recreational land uses. An average occupancy of 2.4 persons /dwelling unit was selected. It is assumed that all septic systems are the same size, treat the same volume of wastewater and export the same amount of nutrients, except that innovative /alternative (I/A) systems are identified and a 50% removal rate for total nitrogen is applied. The model assumes a greater density of ISDS per commercial and industrial land uses to average in the effect of a greater loading from commercial and industrial sites than a residential ISDS.

A more accurate method for determining the loading from large scale ISDS systems was used for existing commercial systems and projected future development in the model, based on the number of persons served, water use (GPD) and effluent concentration. For existing large-flow systems, such as he Job Corps and Marathon house systems, the reported design flow and number of persons served was used to estimate wastewater flows and associated nutrient loading based on a 7 lbs nitrogen and 2.3 lbs phosphorus per person annually. For projected future development, the RI DEM Minimum design standards for Individual Sewage Disposal Systems was used to estimate the design flow based on the type of use and estimated persons served. To incorporate these estimates into the model, the number of ISDS associated with other types of development calculated as a default value was removed and an estimate based on actual numbers of persons using the commercial and industrial land uses were input into the model. This nutrient load was then divided by the loading expected from the standard MANAGE ISDS to determine the equivalent number of “MANAGE ISDS” units per structure. These values were then input into the MANAGE model (Appendix A).

The concentration of nitrogen in residential septic tank effluent is assumed to be 46 mg/l, with 90% of the nitrogen expected to leach into groundwater. This is low since monitoring of demonstration systems by the URI Onsite Wastewater Treatment center indicates that 60 mg/l total nitrogen is representative of residential septic tank effluent. Because of this field data and documentation that commercial septic tank effluent can be much higher in BOD, TSS and nutrients (Higgins and Groves, 1999), we assumed a concentration of 65 mg/l total nitrogen in septic tank effluent from commercial and institutional uses. We also assumed that 50% nitrogen removal was attainable reliably, with 90% leaching to groundwater, resulting in a concentration of 30 mg/l total nitrogen in treated wastewater effluent from advanced wastewater treatment systems. This 50% removal rate was based on the RIDEM Technical Review Committee’s (TRC) policy setting 50% removal and 19 mg/l as the minimum standard for denitrifying technologies. Although the RIDEM permit for the Job Corps recirculating sand filter requires that the effluent concentration not exceed 15 mg/l, the RIDEM TRC has not approved any technology for higher levels of denitrification.

Table 2: Summary of Land Use Scenarios Evaluated using MANAGE

Development Scenarios	Description
Ladd School Study Area	
Ladd 1 – Current	• Total study area /wellhead protection area is 522 acres. • Mapped institutional land use covers 54 acres.[1] • Wastewater flow includes 24,000 gpd design flow from the Job Corps alternative system with 32,050 gpd total institutional wastewater flow, and 4,956 gpd residential /recreation uses.
Ladd 2 - Future	• All institutional land was converted to commercial land (54 acres). • Number of ISDS units increased to service an additional 3,000 persons/day. Total commercial wastewater flow is 77,050 gpd. • All new ISDS assumed to achieve 50% nitrogen removal.
Ladd 3 - Future with Reduced Impervious and Runoff Coefficient	• Same as Ladd 2 (54 acres and 77,050 gpd) and also: • Impervious cover on commercial land use reduced from 72% to 40%. • Runoff Coefficient reduced from commercial to high density residential.
Village Study Area	
Village 1 - Current	• Total study area / wellhead protection area is 220 acres. • Mapped commercial development covers 5.2 acres[1]. • Wastewater flow includes 1,975 gpd commercial and 1,116 gpd residential and recreational.
Village 2 - Future Low	• 50 acres of agricultural land (46 acres cropland and 4 acres pasture) was converted to commercial. • Number of ISDS units increased to service an additional 457 persons/day. Commercial wastewater design flow is 32,050 gpd. • All new ISDS assumed to remove 50% total nitrogen.
Village 3 - Future High	• 100 acres of agricultural land (46 acres cropland, 38.2 acres pasture, and 15.8 acres brush) was converted to commercial. • Number of ISDS units increased to service an additional 1014 persons/day. Commercial wastewater design flow 77,000 gpd. • All new ISDS assumed to remove 50% total nitrogen.
Village 4 - Future High with Reduced Impervious and Runoff Coefficient	• Same as Village 3 (100 acres and 77,000 gpd commercial flow) and: • Impervious cover of commercial land was reduced from 72% to 40%. • Runoff coefficient reduced from commercial to high density residential.
Village 5 - Future High with Low Impervious and Reduced Runoff Coefficient	• Same as Village 3 (100 acres, 77,000 gpd. commercial flow) and: • Impervious cover of commercial land reduced to 25%. • Runoff coefficient and surface nutrient loading coefficients were reduced from commercial to brush. (Represents no net increase in runoff).

Notes:
[1]Current development status taken from RIGIS 1995 Land Use updated with input from Exeter Economic Development Commission members and field surveys.

3.3 Summary of MANAGE Results

3.3.1 Percent Impervious Surface

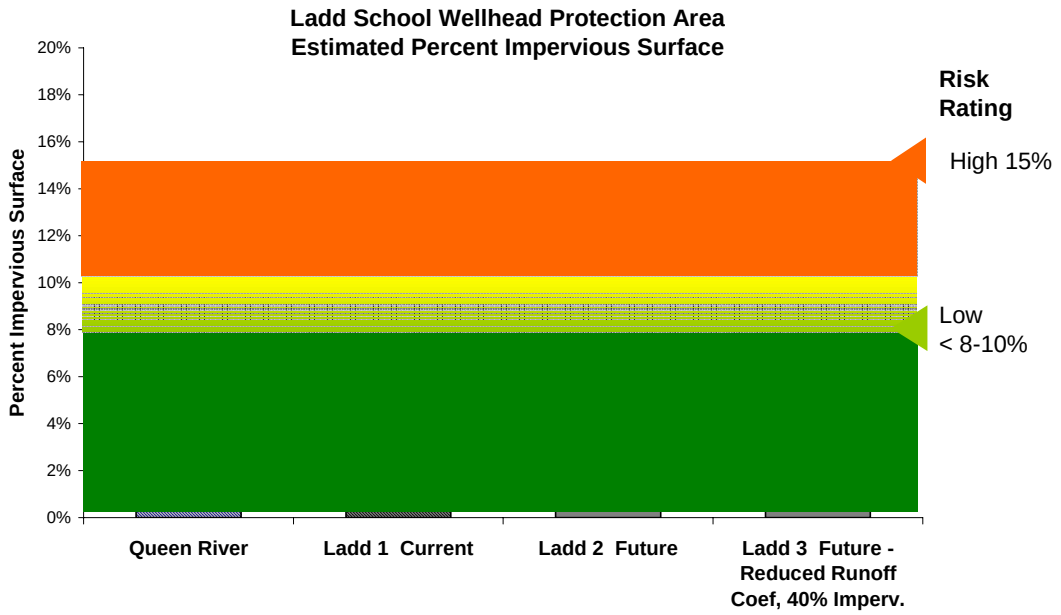
Impervious surface refers to pavement, rooftops and other impermeable material that prevent rainwater from seeping into the ground. Impervious surfaces affect water quality by increasing polluted runoff. Paved areas provide a surface for accumulation of pollutants and create an express route for delivery of pollutants to waterways. Just as importantly, impervious cover alters the natural hydrologic function of the landscape by dramatically increasing the rate and volume of runoff and reducing groundwater recharge.

High levels of impervious surfaces within a watershed lead to “flashier” streams with widely fluctuating water levels, diminished stream flow during critical summer low-flow periods, higher stream temperatures, and increased sedimentation in streambeds, which decreases the capacity of streams to accommodate floods. In streams and wetlands these changes result in loss of habitat, reduced biodiversity and chemical changes in water quality. Without subsurface water infiltration, natural pollutant removal by filtering and microbial activity is bypassed, compounding pollutant delivery. In groundwater recharge areas, impervious cover reduces recharge to deep groundwater supplies.

Numerous studies have linked the extent of impervious surfaces to declining aquatic habitat quality in streams and wetlands (Arnold and Gibbons, 1996; Prince George’s County, 2000). Less than 10 percent impervious surface is considered a low risk to water quality; however, a growing body of evidence indicates that average impervious levels as low as 8 percent can impair the quality of streams supporting cold water fisheries and sensitive macroinvertebrates, such as the Queens River (Center for Watershed Protection, 2002, Azous and Horner, 1997). These studies indicate that watershed impervious surface area greater than 15% is considered a high risk to stream habitat quality.

As an indicator of watershed health, impervious cover is generally measured as an average for relatively small watersheds such as the Queens River watershed and wellhead protection areas. However, the location and “connectedness” of impermeable surfaces is also important. Buildings, roads and parking lots located near wetlands and surface waters are more likely to result in stormwater runoff discharges to nearby waters, especially where runoff from driveways and roads is collected by conventional drainage systems using catchbasins and piping to down gradient basins. Because up to 60 percent of impervious cover is associated with roads and parking (Center for Watershed Protection, 2002), directing new development to more compact growth centers with appropriate infrastructure and land development capability, and reducing lot sizes for more compact development without increasing density are two widely accepted strategies for minimizing environmental impacts while promoting development design using traditional patterns. Although such techniques can result in higher impervious cover locally, total impervious cover is generally reduced overall and environmental impacts reduced when undisturbed open space is considered.

Figure 10 Estimated Percent Impervious Surface, Ladd School



Results – Ladd Impervious Surface and Runoff

Pavement for roads and parking, rooftops, and other impervious cover is estimated to be 2% for the full Queen River watershed. This is well below the 8% level where water quality impacts are expected for sensitive cold water stream habitat and represents a natural "reference" condition for comparison with other study areas.

The Ladd 1 current land use scenario indicates that impervious cover is estimated to be slightly elevated, at 5% as an average for the entire Ladd School wellhead protection area. This is below the 8% low-risk threshold for impacts to stream habitat. However, runoff associated with impervious cover is more likely to have localized impacts to the Queens River when located in close proximity to wetlands and surface waters.

In the Ladd 2 future scenario, the institutional land at Ladd School (54 acres) with estimated 34% impervious cover is converted to commercial development or equivalent use with 72% imperviousness. As a result, the average impervious surface area in the wellhead protection area increases to approximately 9%, considered a moderate risk. This is a concern given the sensitivity of the Queens River habitat and potential for greater localized impacts with proximity of the Ladd School site to wetlands and streams. Although the study site comprises only 10% of the wellhead land use, it is estimated to contribute 36% of the runoff potentially generated from the study area under current land use, and 50% of the runoff under the Ladd 2 future scenario.

The Ladd 3 future scenario demonstrates the benefits of controlling impervious cover and runoff volume. This option assumes the study site (54 acres) is developed at 40% impervious and runoff volume is also reduced slightly using low impact development techniques. Since this is an average for the wellhead protection area, preventing any increase in impervious cover from the current level would better protect surface waters from localized impacts. These estimates are based on RIGIS land use and actual impervious cover determined through field surveys or high-resolution aerial photography may be less than the current estimate of 34% for the Ladd School site..

Summary - Ladd Impervious Surface and Runoff
The total estimated impervious cover for the Ladd School wellhead protection area is estimated to remain below the 10 percent low risk threshold under current and future Ladd School scenarios, but may exceed the 8 percent level considered safe for highly sensitive aquatic habitat such as the Queens River.

The estimated impervious cover is an average for the wellhead protection area, however, under the Ladd 2 future scenario, 50% of the impervious cover within the entire wellhead would be concentrated on the area currently mapped as institutional land use, increasing the potential for impact to the nearby Queens River wetlands.

The future scenarios consider only expanded use of the Ladd school site, not other development of privately owned land in this wellhead area. Impacts are likely to be greater when all other land use changes are considered.

Note: Impervious cover estimates are approximate, based on standard impervious coefficients for various land use types with land use data derived from updated RIGIS land use maps. Actual levels may be measured more accurately using high resolution photographs or development plans.

The Village Study Area

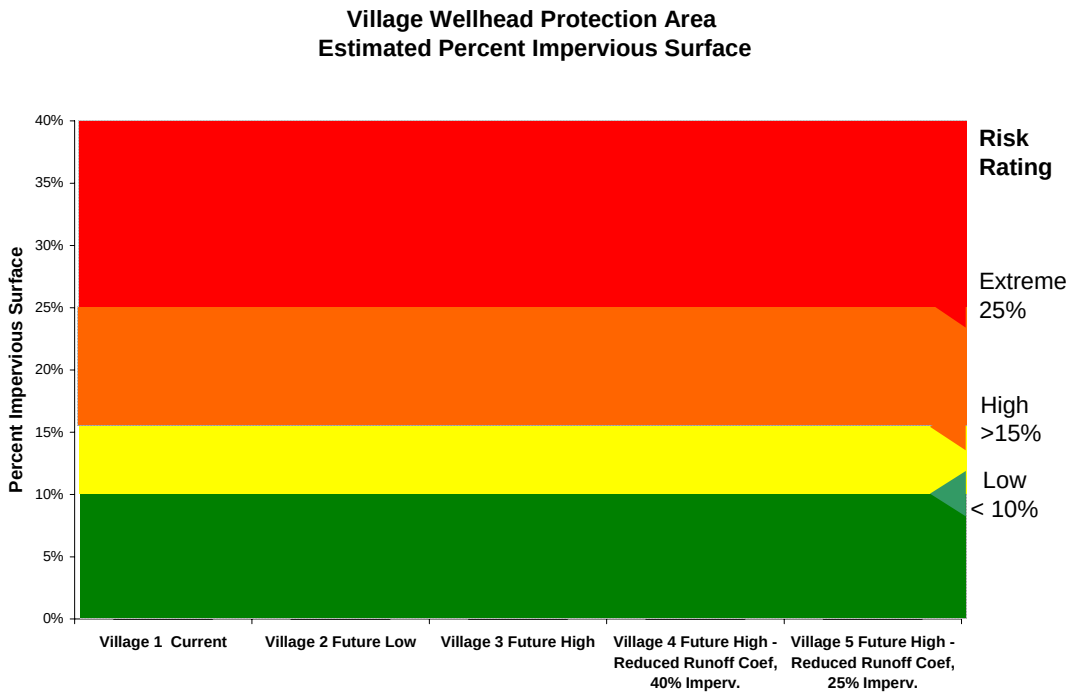
The Village wellhead protection area was examined as an alternative site to the Ladd School property. The concept of directing new growth to this area was first explored by students of the URI Landscape Design program in a studio planning project supervised by Dr. Will Green. The future scenarios we developed to evaluate potential impacts are hypothetical development options based on the concept of creating a new village center further removed from the Queens River groundwater reservoir and sensitive wetlands, in a location that is directly accessible from a state highway. Although the level of development and wastewater loading is comparable to the Ladd School scenarios, the estimated change in pollution risks with the village scenario cannot be compared directly to the Ladd School site due to the following key differences:

- The Village study area encompasses 220 acres, less than half the size of the 522-acre Ladd School site. A small change in impervious surface translates into a greater percentage of impervious in the smaller study area than in the larger Ladd school area. Concentrating impacts in this much smaller area will more than double nutrient loading per acre and impervious cover.

- The total area of commercial development ranges from 50 acres under Village 2 scenario, to 100 acres in the Village 3 future. In the Ladd school area, all new construction and redevelopment occurs on the 54 acre site mapped as institutional land use within the wellhead protection area.

- Converting fields and agricultural use in the Village scenario to commercial use represents a greater change in impervious cover and runoff, from a more natural existing situation, to relatively intense use. In the Ladd school site the difference between impervious surface values for institutional and commercial is much less than that between agricultural and commercial.

Figure 11. Estimated Percent Impervious Surface, Village Study Area



Results – Village Impervious Surface and Runoff

Village 1 represents current land use, with 5 acres of existing commercial development. Typical of lightly developed areas, the impervious cover is low risk at 3%, similar to the Queens River watershed.

Village 2 - Conversion of approximately 50 acres of agricultural land to commercial /mixed use development is expected to increase the average impervious cover for the study area to 20%, assuming conventional development practices with 72% impervious.

Village 3. Further expanding the Village 2 future scenario to include 100 acres of commercial / mixed use development entirely within the wellhead protection area is likely to double the impervious surface area to the extreme risk level of 36%.

Village 4. Reducing impervious cover associated with 100 acres of commercial / mixed use development to 40% has the potential to decrease the total average impervious surface for the study area to the same high risk level as the 50 acre (Village 2) development scenario.

Village 5. Further reducing impervious cover to 25% decrease could potentially reduce the average impervious level for the wellhead protection area to within the moderate risk level.

Summary - Village Impervious Surface and Runoff

Directing new commercial and mixed use development to the Village Wellhead Protection Study Area has the potential to increase impervious cover to high risk levels locally if all new development is sited within the existing wellhead protection area and if conventional development practices are used. This represents a worse-case scenario that is unlikely to occur since Village development is likely to be located at least partly outside the area*.

These results indicate that impervious cover and runoff volume can be controlled through good development practices and stormwater management practices, even with future high intensity development. However, more aggressive controls are potentially much more effective in maintaining stormwater runoff closer to pre-development levels even with more intense development.

Modeled estimates represent average values for the study area. Actual impacts and potential for pollutant delivery to surface waters can be minimized by increasing the buffer distance between land disturbance and nearby wetlands and surface waters.

The potential impacts of future development can be minimized by keeping impervious below 40 - 25 % through site design, use of stormwater controls that treat and infiltrate runoff to maintain pre-development runoff volume, and use of alternative pavements.

Because the hypothetical future development is concentrated in a small study area, the actual change in impervious cover within the surface drainage area flowing towards The Reservoir will be much lower. Increasing the buffer distance between land disturbance and nearby wetlands and surface waters can further reduce potential impacts. Controlling sediment and phosphorus will be a priority, however, water bodies within the Chipuxet River watershed are considered less sensitive to impact than those in the Queens River watershed.

Runoff from high intensity land uses should not be discharged to directly to groundwater within the wellhead protection area, however, this becomes less critical if public water is provided from the Ladd School Wells.

* Approximate boundaries for village development were not available for this analysis.

3.3.2 Nitrate Loading to Groundwater

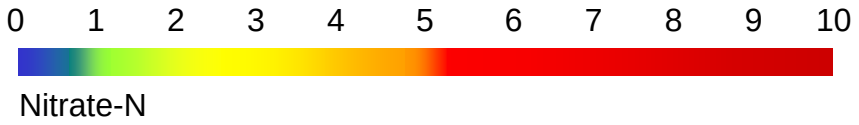
Why Nitrogen is Important

The total amount or load of nutrients generated in a study area is widely used as a measure of pollution risk. Nitrogen is a drinking water contaminant, interfering with the oxygen absorption in infants and causing other health effects. The federal health standard for the nitrate form is 10 mg/L; the drinking water action level of 5 mg/L triggers increased monitoring. Some municipalities in Rhode Island are currently using 5 mg/L as a regulatory limit. Because nitrogen moves readily in the environment, it is also commonly used as an indicator of pollution from human activities, especially when considering impacts to groundwater and coastal waters.

The natural background concentration of nitrate in Rhode Island groundwater is low in stratified drift aquifers, such as the Pawcatuck River Basin, at < 0.2 mg/L (USGS, 1986). A stratified drift aquifer consists of well sorted layers of silt, sand and gravel deposited by melting water from the last glacial period. According to USGS researchers, nitrogen concentrations in Rhode Island groundwater as low as 1 mg/l signal the presence of human impact from either fertilizers or wastewater (DeSimone and Ostiguy, 1999). Because nitrogen is easily dissolved and flows with groundwater, the presence of elevated nitrogen means that other wastewater pollutants such as bacteria, viruses, and organic chemicals also may be present. The level of risk increases with the nitrogen concentration.

Coastal embayments are very sensitive to nitrogen inputs, which acts as a fertilizer to promote excessive growth of algae. Total nitrogen levels in coastal systems greater than 0.60 mg/L N are indicative of eutrophic systems, or systems that are overly nutrient enriched (CCB, 1999). Nitrogen loading from the Pawcatuck watershed, which includes the Queens River, has been estimated to be the major source of nitrogen to the Pawcatuck River Estuary (Desbonnett, 1999). RIDEM has classified estuary waters as impaired, and not meeting acceptable standards for aquatic habitat, due to nitrogen over fertilization. RI DEM has not established criteria for ambient nitrogen levels in RI waters. Freshwaters such as the Queens River are considered more sensitive to phosphorus inputs, however, the effect of increased nitrogen on sensitive aquatic habitat such as that found in the Queens River is unknown. The range of nitrogen concentrations typically found in the environment vs. health standards is summarized in Figure 12 below. Nitrogen is important because concentration well below drinking water levels can indicate increasing pollution risk to sensitive resources and from other dissolved pollutants associated with wastewater and fertilizers such as pathogens, viruses, organic chemicals improperly discharged by septic systems and pesticides.

Figure 12. Understanding Nitrogen Concentrations – What's healthy and safe?



0.2 mg/l —
Rhode Island's natural background concentration in groundwater; healthy coastal waters are near this level or lower.

1 mg/l —
Sign of wastewater or fertilizer in groundwater (U.S. Geological Survey); increasing risk of bacteria and dissolved pollutants.

5 mg/l — Drinking water action level triggering additional monitoring; widely used maximum limit for safety margin.

10 mg/ l — Drinking water standard maximum; acute health effects to infants (blue baby syndrome); suspected risk of miscarriage and other health effects.

Understanding Nitrogen Estimates

In this assessment, nutrient inputs are estimated as the total average annual amount of loading (lbs/yr) of nitrate-nitrogen entering groundwater recharge, and the total amount of nitrogen or phosphorus released to runoff. These estimates represent nutrient sources at the point of origin, not the amount that might ultimately reach a groundwater aquifer, pumping well, wetland or other surface water body. The nitrogen input to groundwater represents the amount of nitrogen percolating into the groundwater with precipitation and septic system effluent. Nitrate loading to groundwater recharge is also estimated as a concentration by diluting the total load with the volume of infiltrating rainwater and septic system effluent. Due to uneven mixing in groundwater we do not assume this concentration will be the same at a pumping well, however, other widely used mass balance models commonly accept this assumption.

Estimated inputs of nitrate-N to groundwater recharge are well documented and based on local research by URI scientists, including Dr. Arthur Gold and others. Although we have confidence in these input values the pathway and fate of nitrogen in the environment is much less certain. Wetland sediments are documented sites for nitrogen removal through microbial denitrification, however, this requires that nitrogen-rich groundwater move via shallow flow through shallow organic sediments in wetlands or riparian buffers with high water table. The opportunity for nitrogen uptake is greater in large watersheds with abundant wetlands, where shoreline buffers are gently sloping with organic sediments as typically found in outwash sites, rather than glacial till, and where pollution sources are further removed from sensitive receiving waters. The potential for nitrogen removal is lower in wellhead protection areas where nitrogen enters groundwater as recharge to a pumping well without treatment in wetlands. In these wellhead protection areas it is assumed that over time the quality of the underlying groundwater will begin to reflect the quality of recharge water entering the wellhead.

Existing Conditions - Monitored Nitrogen levels

Monitored groundwater nitrate levels are generally low but show signs of impact from wastewater or fertilizers. Nitrate-N concentrations in the public wells operating in the Ladd School area range from 0.06 to 2.4 ppm (mg/L), with the average nitrate-N concentrations for each well ranging from 0.15 to 1.16 mg/L. Low level detections of organics and inorganics were also observed, with only one exceedance recorded. One copper sample reported at 1.7 mg/L copper exhibited concentrations that were above the RI Department of Health Advisory Level of 1.3 ppm copper. This data was obtained from the Rhode Island Department of Health and collected between 1988 and 2004. These results indicate that nitrate concentrations in the Marathon House well are generally at background concentrations. Nitrate-N levels in the Job Corp wells are well below levels where public health is a concern, although nitrate is slightly elevated, indicating the presence of fertilizers and/or wastewater effluent.

Groundwater monitoring of shallow wells installed as a requirement with approval of the Job Corps wastewater treatment system indicate slightly higher nitrate-N concentrations generally ranging from 1.0 to 1.4 mg/l (Aldinger sampling results 1/30/04 and 2/11/04). One groundwater monitoring well installed up gradient of the Job Corp wastewater treatment system tested “somewhat high for nitrate (2.6 to 2.9 mg/l). The well is closer to disturbed (i.e. already developed) portions of the site, including the adjacent open fields and landscaped areas, which may account for the higher than expected background level here” (R. Chateauneuf, Chief of Permitting, DEM Division of Water Resources, email to Eugenia Marks, RI Audubon, 4/21/04.)

These estimates suggest that fertilizer applications are influencing groundwater nitrogen levels at least locally, which must be considered when evaluating impacts of future development.

Table 3: Rhode Island Department of Health Historic Well Water Quality Data

Nitrate levels in Job Corp wells (former Ladd School wells) over period of record

Rhode Island Community Living and Support - Exeter Job Corps (Well ID 1592012)

Sample Date	SOURCE NAME	Nitrate as N (ppm)
9/28/1988	GRVL. PACKED WELL # 3	0.80
4/24/1990	GRVL. PACKED WELL # 3	0.30
4/8/1991	GRVL. PACKED WELL # 3	0.60
4/6/1992	GRVL. PACKED WELL # 3	0.70
12/8/1993	GRVL. PACKED WELL # 3	0.90
11/4/1994	GRVL. PACKED WELL # 3	1.00
7/27/1999	GRVL. PACKED WELL # 3	1.32
9/18/2000	GRVL. PACKED WELL # 3	1.30
10/23/2002	GRVL. PACKED WELL # 3	2.40
9/17/2003	GRVL. PACKED WELL # 3	1.80
8/10/2004	GRVL. PACKED WELL # 3	1.60
	Average	**1.16**
	Maximum	**2.40**
	Minimum	**0.30**
	Number of Data Points	**11**

Rhode Island Community Living and Support - Exeter Job Corps (Well ID 1592012)

Sample Date	SOURCE NAME	Nitrate as N (ppm)
9/28/1988	WELL #2	0.40
4/24/1990	WELL #2	< 0.10
4/8/1991	WELL #2	0.80
4/6/1992	WELL #2	1.20
12/8/1993	WELL #2	0.50
11/4/1994	WELL #2	0.70
12/4/1995	WELL #2	0.30
11/14/1996	WELL #2	0.30
11/25/1997	WELL #2	0.20
3/22/1999	WELL #2	0.20
8/11/1999	WELL #2	0.47
9/18/2000	WELL #2	0.30
10/23/2002	WELL #2	1.20
9/17/2003	WELL #2	0.23
8/10/2004	WELL #2	0.41
	Average	**0.49**

Maximum	**1.20**
Minimum	**0.10**
Number of Data Points	**15**

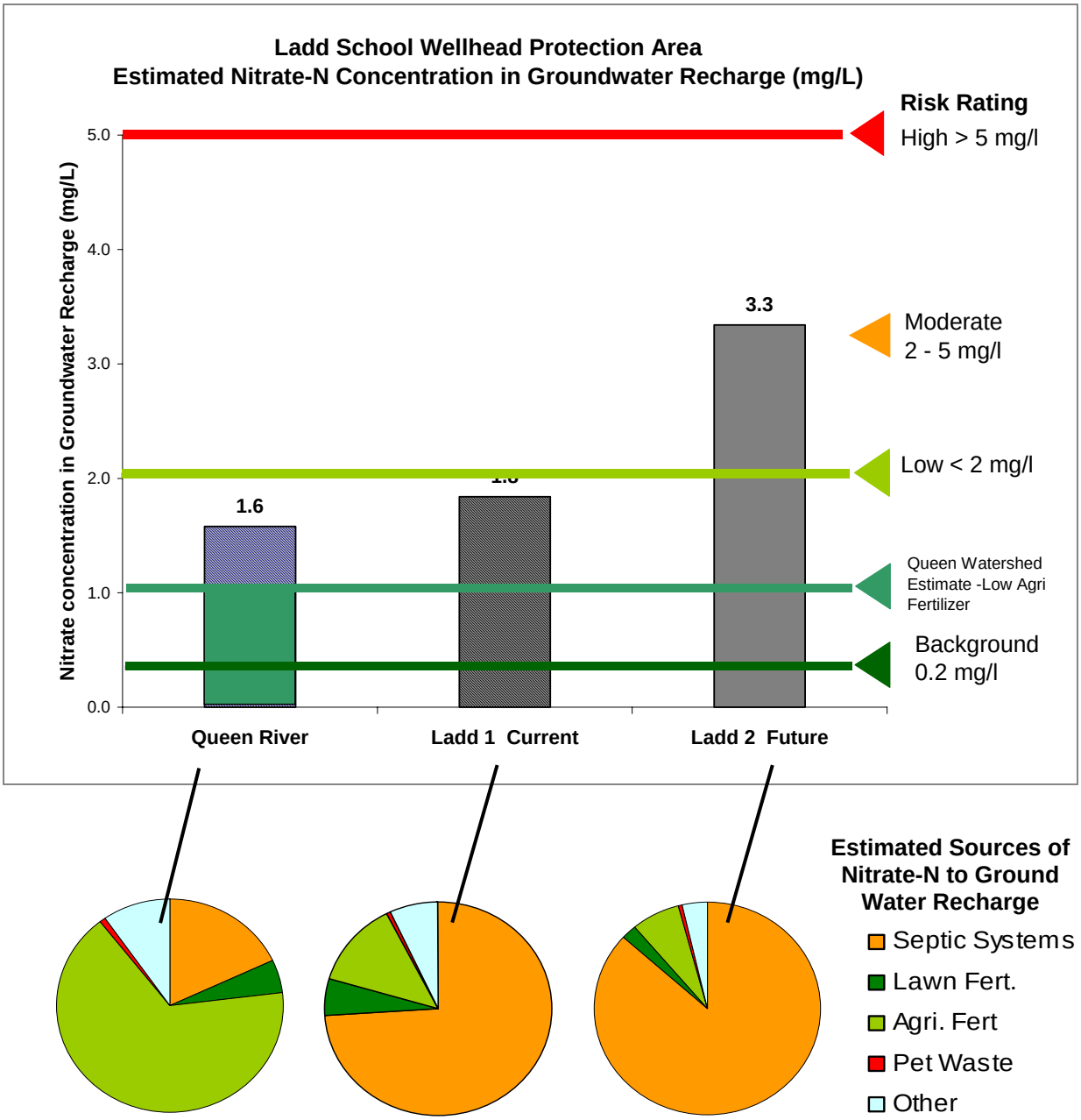
Table 3: Rhode Island Department of Health Historic Well Water Quality Data (Continued)

Marathon House (Well ID 2980264)

Sample Date	SOURCE NAME	Nitrate as N (ppm)
10/25/1994	DRILLED WELL	0.20
10/7/1997	DRILLED WELL	0.20
10/19/1998	DRILLED WELL	0.20
2/24/1999	DRILLED WELL	0.40
2/22/2000	DRILLED WELL	0.10
1/3/2001	DRILLED WELL	0.12
2/12/2002	DRILLED WELL	0.10
2/3/2003	DRILLED WELL	0.07
1/8/2004	DRILLED WELL	0.08
1/25/2005	DRILLED WELL	0.06
	Average	**0.15**
	Maximum	**0.40**
	Minimum	**0.06**
	Number of Data Points	**10**

Notes:
MDL = 0.1 ppm
Values less than MDL are calculated into the average concentration as the value of the MDL.
Drinking water action level = 5 ppm
Drinking water standard = 10 ppm

Figure 13. Estimated Concentrations and Sources of Nitrate-N to Groundwater Recharge – Queens River Watershed and Ladd School, Current and Future Scenarios



Results – Ladd Estimated Nitrate Loading to Groundwater Recharge

The Queens River watershed serves as reference for comparing nitrogen inputs from a relatively undeveloped watershed with the Ladd school current and future scenarios. Here estimated nitrogen inputs to groundwater recharge are low, ranging from 1.0 mg/l to 1.6 mg/l nitrate-N under current land use. The high estimate assumes land mapped as cropland receives a high fertilizer application of 215 lbs/acre with 30% leaching to groundwater, the amount expected with corn production. The low estimate assumes 175 lbs/acre annually, with 20% leaching to groundwater, a lower amount typical of turf production. Since much of the agriculture in the watershed is turf, the lower value may be more realistic. In both cases, the estimated concentration represents the total amount leaching into groundwater, diluted with rainfall after accounting for runoff and evapotranspiration. This does not take into account nitrogen treatment through natural processes, such as uptake by plants or microbial denitrification likely to occur in wetlands.

As expected in a rural area, agricultural fertilizers are considered the major source of nitrogen to groundwater in the Queens River watershed, contributing up to 64% of the total amount, with septic systems estimated to contribute 20% of the total. Lawn fertilizers, pet waste, and nitrogen from atmospheric deposition in naturally vegetated, unfertilized areas are estimated to be minor sources.

Under current land use (Ladd 1), the estimated concentration of nitrate-N entering groundwater in the Ladd wellhead protection area averages 1.8 mg/l, still below the 2 mg/l threshold ranked as a low risk to groundwater. However, the major sources of nitrogen in the current Ladd scenario are reversed, with septic systems expected to contribute 74% of the total nitrate-N entering groundwater recharge, and agricultural fertilizers estimated to contribute 13%.

The future scenario (Ladd 2) indicates that effluent volume discharged to groundwater will more than double, resulting in a potential increase in nitrate-N inputs to 3.3 mg/l nitrate-N. This is calculated as an average for the entire wellhead area while in reality, the wastewater effluent will be more highly concentrated in effluent plumes from onsite wastewater treatment systems. Although ranked as a moderate risk, this is a much greater threat within the area affected by effluent plume(s).

The nitrate sources to groundwater recharge for both the current and future scenarios for Ladd School illustrate that most of the nitrate load to groundwater recharge is expected to come from septic systems, as shown in the pie charts in Figure 13 and in Table 3 above. This shift from fertilizers to wastewater as the main source is a concern because wastewater discharged below the root zone and in coarser soils have much less potential for natural removal than fertilizers applied to the ground surface where microbes in organic-rich topsoil and plants have the opportunity to remove nitrogen, as well as phosphorus and other contaminants. Shallow, pressure-dosed drainfields used with alternative systems can improve, but not completely restore this natural treatment function. The potential for impact is compounded if stormwater discharges are conveyed directly to wetlands and surface waters without the benefit of infiltrating through soils where natural pollutant removal processes can occur.

Summary – Ladd Estimated Nitrate Loading to Groundwater Recharge

Effluent volume discharged to groundwater is expected to double from current levels in the Ladd study area to the future scenario. This does not take into account any new development on non-institutional land within the wellhead.

Nitrogen inputs to groundwater are expected to increase almost two-fold with future development. Estimated nitrate-N concentrations are average values for the wellhead protection area; however,

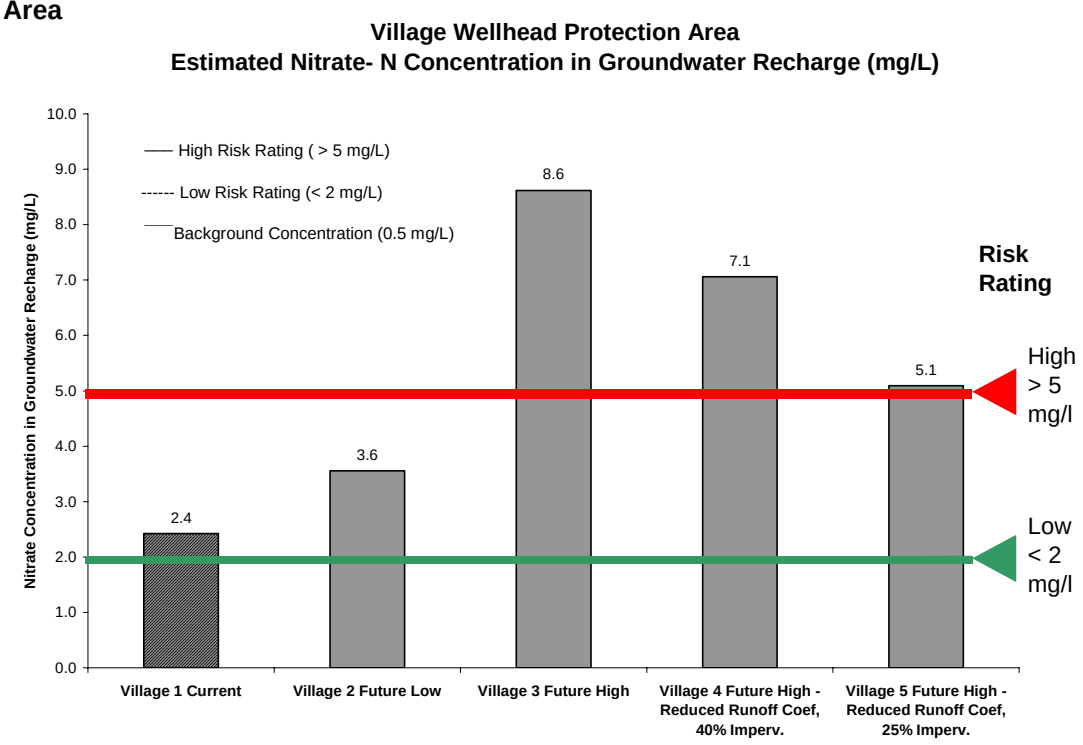
wastewater pollutants will be concentrated at much higher levels in effluent plumes from onsite wastewater treatment systems. The existing public wells are at low risk of impact from the Job Corps wells due to the separation distance from this wastewater treatment system – more than 1000 ft from the Job Corps wells and approximately ½ mile from the Marathon House. The Marathon House onsite wastewater treatment system appears to be located within the

The most serious concerns are the risk of effluent movement to the Queens River system and local contamination of the groundwater reservoir for future water supply. The plume analysis conducted by the consulting firm of Fuss & O'Neill (described in part 4 of this report) estimates that the nitrogen concentration from the existing onsite wastewater treatment system at the Job Corp training center will exceed the drinking water standard of 10 mg/l will be reached at the property boundary, and that the drinking water action level of 5 mg/l will be reached at the Queens River. In addition, these consultants projected that concentrations of phosphorus – the key nutrient likely to degrade fresh water aquatic habitat due to excessive growth of algae and weeds – will reach the river in concentrations high enough promote nutrient enrichment.

Hydrologic and nutrient loading assumptions used in the plume analysis are generally consistent with those used in this MANAGE assessment except that we assumed a higher concentration of nitrogen in the treated effluent than used in other modeling studies. Long term monitoring of demonstration systems by the URI Onsite Wastewater Training Center indicates that septic tank effluent in domestic wastewater averages approximately 65 mg/l total nitrogen. Septic tank effluent from office buildings and other commercial uses in Massachusetts were found to have total nitrogen concentrations exceeding 100 mg/l, with middle school wastewater effluent ranging from 50-100 mg/l (Higgins and Groves, 1999).

Monitoring data for the Job Corps system was unavailable from contractors hired to conduct system maintenance (Justin Jobin personal communication, April 2005, and Bob Johnson, Atlantic Solutions, June, 2005) and it is not clear what procedures are in place for review and use of the data. Quarterly monitoring of the Job Corps wastewater effluent is required, which would mean sampling should have been conducted at least twice since the system was brought on line in November 2004. However, according to the system designer, the system has received light use and may not achieve optimum performance when actual flow differs from the design flow (Brian Thalman, personal communication, June, 2005). Without data on wastewater characteristics and actual treatment performance of the Job Corps wastewater treatment system, we assumed a septic tank effluent concentration of 65 mg/l total nitrogen, with treated effluent of 32 mg/l TN, based on 50% removal. Fuss & O'Neill used 15 mg/l total nitrogen in their plume analysis, based on the RIDEM ISDS permit approval for the Job Corps system setting the maximum effluent limit of 15 mg/l total nitrogen. Standard references (Metcalf & Eddy, 1991), cite 25 mg/l as the expected concentration of total nitrogen in recirculating sand filter effluent. In addition, the actual performance can be expected to vary depending on the total amount of flow, type of waste, variability in the wastewater stream and level of care in operation and maintenance. For example, EPA reports a range of typical septic tank effluent from recirculating media filters as 10-30 mg/l total nitrogen. A concentration of 15 mg/l total nitrogen is possible depending on the influent concentration and if careful operation and maintenance. Consequently, the Fuss & O'Neill plume analysis may be considered a best case scenario provided the system consistently achieves the 15 mg/l standard.

Figure 14. Estimated Concentration of Nitrate-N to Groundwater Recharge, Village Study Area



Results –Estimated Nitrate Loading to Groundwater Recharge, Village Area

The Village scenarios represent the worst-case situation whereby all new development, including wastewater treatment systems, is located within the existing Village wellhead protection area. In all future scenarios, the primary source of nitrate-N to groundwater is expected to shift from agricultural fertilizers to septic systems.

Existing nitrogen inputs to groundwater are estimated to be in the moderate range under current land use, increasing to high risk levels with more intense development under the Future "High" Village 3 scenario. These estimates represent sources only, without considering removal through natural processes, which is likely to be highest under current, relatively undeveloped conditions.

All future scenarios assume alternative treatment systems would be used to remove 50% total nitrogen. Certain pre-fabricated treatment systems, such as membrane filtration systems can be designed to generate a much higher quality effluent suitable for water reuse and recycling for flushing or drip irrigation.

The Village 2 "Low" option represents commercial development on 50 acres, with wastewater flows comparable to the current design flow from the Ladd center.

The Village 3 "High" option represents high intensity use, with total wastewater flows comparable to the Ladd 2 Future option, spread on 100 acres. The potential increase in average nitrogen concentration to the high risk level is a serious concern. Because effluent would be concentrated in wastewater plumes from onsite systems, each leachfield site would have to be evaluated. Village scenarios 2 and 3 assume standard stormwater system design with 72% impervious cover on commercial land use, with associated increased runoff.

Village 4 and Village 5 future options illustrate the potential benefits of using better design to reduce impervious cover. Village 5 restricts impervious cover of commercial development to 25%,

and assumes runoff volume is maintained at pre-development levels using infiltration techniques. The Village 5 option represents a situation of “no net increase in runoff volume” which may be difficult to achieve under all circumstances but is a realistic treatment standard using updated stormwater design methods. The differences in nitrate concentration in groundwater recharge between scenarios 4 and 5 are mainly related to changes in recharge volume. With less impervious surface there is a greater recharge volume, diluting the nitrate load and providing opportunity for additional treatment through natural processes.

The reduction in nutrient loading for the Village 4 and 5 scenarios suggest that keeping impervious cover at a maximum of 25%, and maintaining recharge volume as close as possible to pre-development levels are effective strategies for protecting groundwater quality.

The estimated average nitrogen concentration for the wellhead protection area, at 5.1 mg/l in the Village 5 scenario, is still considered high risk. Additional mitigation measures may therefore be necessary, such as locating onsite wastewater treatment systems at least partly outside of the watershed, or using advanced treatment systems capable of higher treatment efficiencies.

3.3.3 Phosphorus Loading

Phosphorus Loading to Surface Runoff

Phosphorus is the primary nutrient responsible for over fertilizing freshwater lakes, ponds and streams. Although phosphorus is essential for algal and aquatic plant productivity, even minute increases in the amount of phosphorus can trigger tremendous increases in growth. The natural background concentration of phosphorus in Rhode Island water is 15 parts per billion, which is equivalent to 0.015 mg/L (URI Watershed Watch long term monitoring data). Lakes with low phosphorus concentrations generally have good water clarity with few aquatic weeds and algae. The RIDEM maximum average total phosphorus standard for freshwater lakes and reservoirs is 25 ppb. However, the Carlson Tropic Index, a widely used index of nutrient enrichment in surface waters, ranks lakes with 25 ppb as over-fertilized and likely to have overabundant growth of algae and aquatic plants. Consequently, the current RIDEM standard for phosphorus may not be adequate to prevent degradation of surface waters. This is especially a concern for the sensitive and unique aquatic life found in the Queens River.

The estimated phosphorus load to surface runoff with the development of the Ladd School area is approximately 0.4 lbs/acre/year. It is difficult to estimate the potential change in phosphorus loading with more intense development because the phosphorus runoff coefficients representing the current institutional land use and the more intensive, commercial-type use possible under the Ladd 2 scenario is not substantially different.

At the Village site, the potential phosphorus loads to runoff are expected to vary little between the current conditions with the Future “Low” option because the phosphorus coefficient for the current agricultural use is similar to commercial use, resulting in approximately 0.6 lbs/acre/yr. However, as noted in the nitrogen discussion however, the actual amount of phosphorus reaching surface waters may be much greater with commercial development where drainage systems are used to convey runoff to nearby storm drains and wetlands unless stormwater systems are specifically designed to remove fine sediment and phosphorus.

In the more intensely developed Scenario Village 3, the conversion of brushland to additional commercial land is estimated to increase the phosphorus load to the high risk level of 0.8 lbs/acre/year because the phosphorus loading factor for brushland is much lower than that of commercial land. The combination of decreasing the impervious cover to 25% and reducing the estimated runoff volume for the commercial land use (Scenario Village 5) is the most effective in

reducing phosphorus loading to pre-development levels. This scenario represents the best-case situation of no-net increase in runoff volume.

In both the Ladd and Village study areas, site-specific information on the location and intensity of land development is needed to better characterize hydrologic changes with various land use designs and with different types of stormwater treatment systems. Although MANAGE provides initial information on relative stormwater runoff impacts, more specialized hydrologic models are better suited to this purpose than MANAGE, which is a screening level analysis for use at the subwatershed /wellhead protection area scale.

Potential impacts to nearby surface waters and wetland, especially from phosphorus and sediment in surface runoff, can be reduced by protecting naturally vegetated wetlands buffers. In a review of wetland buffer water quality function, URI researchers concluded that at least 300 feet is a generally effective buffer distance for removing up to 80% of phosphorus, with greater setbacks required for wildlife habitat protection greater (Desbonnet et.al., 1999).

The current water quality standard for stormwater treatment under the RI Stormwater Design and Installation Manual (RIDEM 1993) requires 80% removal of suspended solids. This is a minimum standard that does not regulate nutrient removal, and they are not designed to control the total amount, or volume of runoff. These are an improvement over basic flood controls previously in effect. In the 13 years since the stormwater standards were adopted, the treatment efficiency of conventional stormwater treatment systems has been shown to be highly variable and often inadequate. Table 4 summarizes expected percent pollutant removal efficiencies for various types of stormwater systems based on national monitoring data. Stormwater systems that meet the RIDEM 80% TSS rule are highlighted. Results show that phosphorus and nitrogen removal is highly variable and often very low. Systems achieving a high degree of phosphorus removal (80%) include the infiltration trench and bioinfiltration. These systems also have the benefit of recharging groundwater to promote natural removal processes and maintain groundwater quantity. Various technologies may also be used in sequence to achieve the desired level of treatment.

Table 4. Pollutant Removal Rates of Stormwater Treatment Systems

Percent Pollutant Removal Rates of Stormwater Treatment Systems

Treatment Type	Total Suspended Solids	Total Phosphorus	Total Nitrogen
Grass Buffer (75 ft)	54	-25	NA
Grass Buffer (150 ft)	**84**	40	NA
Grass Channel	**81 +-14**	34 +- 33	NA
Dry Extended Detention	NA	20 +- 13	31 +- 16
Wet Pond	**80 +- 27**	**51 +- 21**	33 +- 20
Pond / Wetland system	71 +- 35	56 +- 35	19 +- 29
Sand Filters	**86 +-23**	59 +- 38	38 +- 16
Infiltration Basin	75	60-70	55-60
Infiltration Trench	NA	**100**	42.5
Bioinfiltration	**90**	**70 - 83**	**68 - 90**

Source: Adapted from Stormwater Managers' Resource Center (SMRC) 2000. Fact Sheets: Stormwater Management Practices. [Online] Available at: http://www.stormwatercenter.net/. Verified on 27 August 2003. Bioretention rates from 1 Davis et al. (1998); 2PGDER (1993) cited in EPA Storm Water Technology Fact Sheet (1999)

Recognizing the need to address these deficiencies, RIDEM has drafted updated stormwater standards. These provide guidance on designing stormwater basins to remove finer sediment particles typically associated with increased phosphorus. And they incorporate up-to-date stormwater management methods using small scale, nonstructural stormwater systems that are incorporated into early project design using for example, swales, leaching chambers for rooftop runoff, diverting runoff to vegetated areas, and small bioinfiltration basins. Engineered stormwater basins would be used only after these options have been fully utilized.

Because RIDEM standards are minimum, RI municipalities have the authority to adopt more stringent standards to control cumulative impacts associated with land use and to protect sensitive water resources. Local controls can include standards for nutrient removal and control of runoff volumes. The town can also require use of small scale nonstructural controls that are less costly to maintain, and limit use of wetponds where stormwater discharges with elevated temperatures can impair cold water streams.

Phosphorus from Onsite Wastewater Treatment Systems

The MANAGE assessment method is not designed to estimate phosphorus inputs to groundwater because phosphorus is generally associated with sediment in stormwater runoff, where the sources are generally erosion of soil from farming, construction, and fertilizers. Phosphorus inputs to groundwater from individual septic system is generally not considered a serious concern provided adequate separation distance is provided between the bottom of the leach field and groundwater, and horizontal setbacks are maintained to wetlands and surface waters. Phosphorus from septic systems is therefore a concern in high water tables where phosphorus becomes mobile, with shoreline development, and especially for large onsite wastewater discharges where phosphorus movement can occur after the maximum capacity of soils to adsorb phosphorus is saturated. In this case it is only a matter of time before phosphorus plumes can reach nearby wetlands and surface waters, with greater buffer distances providing a longer time frame for phosphorus movement as well as increasing opportunity for loss through plant uptake.

Advanced wastewater treatment systems most commonly used in Rhode Island are designed to reduce BOD and TSS and can be configured to reduce total nitrogen and/or bacteria. Long term monitoring of advanced wastewater systems constructed as demonstration systems by the URI Onsite Wastewater Training Center show that these technologies provide very little removal of phosphorus, although shallow drainfields located with root zones can be expected to provide some phosphorus removal by plant uptake.

Table 5: Total Phosphorus Concentrations in Treated Wastewater Effluent from URI Demonstration Systems

Demonstration systems monitored by URI Onsite Wastewater Training Center 1998- 2004

Site ID	**Effluent Sample Location**	**TP Conc. Mean (range)** mg/L	**Mean TP Reduction** %
1 G	Textile filter-ME	9 (8 - 11)	n/a
	Bottomless sand filter	9 (8 - 11)	0
2 T	Textile filter-Recir	18 (15 - 21)	2
5 M	Textile filter-Recir	16 (12 - 15)	0
4 H	SP Sand filter	5 (3 - 5)	40
6 S	Peat filter	10 (9 - 11)	5
7 T	F. activated sludge unit	6 (4 - 7)	n/a
USEPA, 2002	STE	(8 - 22)	

As shown above, EPA reports that the typical concentration of total phosphorus ranges from 8 to 22 mg/L in septic tank effluent (table 5). This can be expressed as 8,000 to 22,000 ppb total phosphorus. As noted above, this compares to the 25 ppb DEM standard for lakes and the 10 ppb threshold for high quality lakes using the Carlson Trophic Index. Results of system monitoring show that only the single pass sand filter achieved significant reduction of total phosphorus, with treated effluent averaging 5,000 ppb. Other systems, including single pass textile filter, recirculating textile filter, peat filter and Fixed activated sludge treatment units reduced phosphorus by 0 to 5 percent. Except for the single pass sand filter, total phosphorus in treated wastewater effluent averaged 6,000 to 18,000 mg/L. Using a bottomless sand filter for final dispersal of wastewater also did not provide additional phosphorus reductions.

We were unable to obtain data on treatment performance of the Job Corps wastewater treatment system. Because the function of this recirculating sand filter is similar to the recirculating textile filter, we would expect treated effluent concentrations to be similar, in the range of 15,000 to 21,000 ppb, with little phosphorus removal. This is approximately 1000 times greater than the 25 ppb DEM standard for lakes. Improving phosphorus treatment from onsite systems is currently an area of active research. It is also likely that pre-fabricated wastewater treatment units such as Membrane Filtration Systems commonly used for larger flows can be designed to provide a higher level of treatment for both phosphorus and nitrogen than the small scale technologies monitored by URI.

3.3.4 Pollution Risks from Onsite Wastewater Treatment Systems

Nutrient loading estimates indicate that onsite wastewater treatment systems are by far the major source of nutrients under current development at the Ladd school site, and wastewater effluent is expected to become a more significant source with future development. As a result, managing pollution risks from onsite wastewater treatment systems is basic to controlling environmental

impacts overall. According to the U.S. Environmental Protection Agency (2003) pollution threats from onsite wastewater treatment systems can be broken down into four different types of risk, with the need for proper system management increasing with each factor. As described below, wastewater treatment in the Ladd School area involves all four types of risk.

Environmental sensitivity – potential impact to unique or sensitive habitat. The Queens River system is considered extremely sensitive to phosphorus inputs at extremely low concentrations. The job corps wastewater treatment system is not designed to remove phosphorus, which is discharged at approximately 1000 times the 25 ppb DEM standard for lakes. Recent estimates by the engineering consulting firm of Fuss and O'Neill indicate that the natural ability of soil to remove phosphorus from the Job Corp effluent plume will be quickly saturated and that phosphorus from untreated effluent will reach the river at concentrations exceeding safe levels.

Public health – potential threat to drinking water supplies or recreational contact where public health standards apply. The Ladd School property is located entirely within the Queens River groundwater recharge area with portions overlapping the groundwater reservoir, where well yield is considered greatest. Any new wastewater treatment system will introduce an additional pollution source to groundwater supplies with risk of contamination while further eliminating options for siting new public wells. Currently, the Marathon House wastewater treatment system appears to be located within the Job Corps wellhead protection area. The Job Corp system is centered within the most productive portion of the Queens River groundwater reservoir, eliminating this area from future use for drinking water supply.

Wastewater characteristics – high strength waste and large flows are more difficult to treat than domestic wastewater from individual systems, and requires additional precautions to ensure proper system function. Institutional and commercial uses at the Ladd School site raise several concerns.

Restaurant waste – Fats, oil and grease, combined with periodic high flows, make kitchen waste notoriously difficult to treat while the volume of wastewater from the large Job Corps cafeteria adds to the challenge. Training and oversight of staff is needed to prevent solids and grease from being deliberately washed down the sink. Frequent maintenance of grease traps, effluent screens and tanks is needed to protect the drainfield.

Laundry waste is difficult to treat with onsite systems and as a result, commercial laundromats are not permitted to discharge to an individual sewage disposal system under RIDEM ISDS regulations (S.D. 2.18).

High failure rates due to high flow and high-strength waste from institutional facilities led URI researchers, in cooperation with State agencies, to select state-owned community living centers as research sites in new study of remediation methods for large drainfields.

Uncertainty over type of wastes – In collecting existing data for this assessment, we were unable to obtain information about current or future activities, and type of waste that might be generate at the Ladd School site. This is a concern since any use of hazardous materials is a concern in this groundwater recharge area. Will training activities at the Job Corp site have the potential to generate wastes that may impair system function or increase risk of groundwater contamination? Are additional precautions needed to avoid groundwater contamination such as use of holding tanks or additional pre-treatment for potentially toxic wastes? Are training and maintenance procedures in place to reduce risk of spills or improper disposal? For new facilities that may be sited within the Ladd School area, will use of hazardous materials be prohibited or regulated, and what review, inspection and compliance process will be implemented?

Treatment complexity – advanced treatment systems with pumps, mechanical and electrical components, all need a higher degree of maintenance than conventional gravity-flow systems.

The RIDEM permit approval requires that a maintenance contract be established but it is a local responsibility to ensure the contract remains in place and that all maintenance and repairs are properly carried out.

The EPA management guidelines (EPA, 2003) recommends the highest level of management for situations, such as the Job Corps system, where all four risk factors are involved, where a responsible management entity is selected to reliably maintain the system under the supervision of state or local regulators. In Rhode Island, municipalities have the responsibility to ensure that onsite systems are properly maintained, but without a without a local wastewater management program in place, it is not clear how the Town of Exeter will ensure that wastewater treatment systems are properly maintained over the long term. Under a local septic system inspection and maintenance program, a municipality would send reminders of required maintenance, receive and review inspection results, conduct spot checks to ensure the work was done properly, set deadlines for required pumpouts and repairs, and enforce compliance with requirements. Results of groundwater monitoring data and effluent monitoring should be reviewed and provided to maintenance providers as feedback to enhance systems performance. Given that the approved effluent limit is 15 mg/l total nitrogen, what action is triggered if these levels are exceeded? If the town assumes responsibility for overseeing management of the wastewater treatment systems at the Ladd School site, town staff or a town contractor will be needed to track maintenance, send reminder notices and enforce compliance. A funding source is needed to cover this expense, either through initial application fees, annual fees to the system owner, or general tax revenues.

4.0 SUMMARY OF MODELS COMPLETED BY OTHER PARTIES

Models are best approximations of reality, based on assumptions that may or may not hold true in different environmental situations. Since models are based on assumptions, the model export will only be as good as the assumptions. Several models were used in an attempt to determine potential impacts of development of the Ladd School site on groundwater nitrate concentration, as listed below. It is important to note that those described as a "mass loading" or "mass balance" model are similar to the MANAGE approach in that nutrient sources for an area are calculated as an average for a site. This type of analysis is best used to compare the relative change in results with different scenarios, rather than an absolute value. The RIDEM Method 1 model calculates a concentration within an estimated plume area. This is a more specialized approach that can be further refined using field data for model input parameters.

- July 2000 – Paul B. Aldinger and Associates, Inc. – Mass Loading Model of Former Ladd School site. (Geohydrological Report on Former Joseph H. Ladd Facility, Exeter, RI July 20, 2000)

- June 2001 – Paul B. Aldinger and Associates, Inc. – RIDEM Method 1 Model (Aldinger and Associates, Inc. Nitrate Loading Study for the Proposed Job Corps Center, Exeter, RI June 2001).

- October 2001 – Paul B. Aldinger and Associates, Inc. – RIDEM Method 1 Model and Mass Balance Models (Aldinger and Associates, Inc. Supplemental Nitrate Loading Study for the Proposed Job Corps Center, Exeter, RI, October 2001).

- June 2004 – Fuss and O'Neil – RIDEM Method 1 model (Fuss and O'Neil. Job Corps Hydrologic / Water Quality Review, Town of Exeter, Exeter, RI, June 2004).

4.1 Overview

The modeling studies presented above used methods that can be placed into two basic categories: models using the RIDEM Method 1 (Table 6, Models 1a, 1b, 1c and 3) to evaluate nitrogen concentrations within a wastewater plume, and those using a mass balance approach to estimate nitrogen loading over a larger area. (Table 6, Models 2, 4 and 5). The areas used for the mass balance models are shown in Figure 15, but the smaller areas used to evaluate plume concentrations are not shown.

The main parameters of interest in each model that provide the greatest indication of differences between the models are: groundwater recharge volume, total nitrate to groundwater and treated ISDS effluent concentration for the Job Corps system. In some cases, differences in two or more assumptions tended to cancel each other out, resulting in only minor differences in the final results.

Plume analysis models: All the models employing the RIDEM Method 1 (Models 1a, 1b, 1c and 3) reported values for groundwater recharge volume and total nitrate to groundwater within the same order of magnitude. Assumptions regarding precipitation, waste water loading volume and concentration, and the study area are responsible for differences in the reported hydrologic and nitrate loading for each model. The ISDS effluent concentration values from the Job Corps recirculating sand filter were very similar, ranging from 10 to 15 mg/L NO_3-N.

- None of the RIDEM Method 1 models appear to include fertilizer leaching to groundwater. Groundwater monitoring prior to construction of the Job Corp septic system indicates that groundwater nitrate levels are slightly elevated due to either fertilizers or wastewater discharges, at concentrations generally between 1 - 1.4 mg/l, but as high as 2.9 mg/l. Factoring in fertilizer inputs will result in higher nitrogen loading estimates.

- The Aldinger Method 1 models assume 90% of precipitation will infiltrate over developed portions of the study area. This represents a no-net increase in runoff scenario which the Fuss & O'Neill consultants suggested was not representative of actual conditions based on use of conventional storm drainage systems rather than infiltration systems. The Aldinger models also use 48 inches of rainfall, vs. 45 inches used by others, also resulting in a lower nitrogen leaching value.

Mass balance models (Models 2, 4 and 5) are intended to evaluate the combined impacts of all land use and onsite wastewater discharges within a study area. Results for these models varied in total groundwater recharge volumes, total nitrate to groundwater and treated ISDS effluent concentration. Since the models analyzed extremely different study areas (20 acres to 522 acres) the hydrologic and nutrient loading values for each model are best evaluated as total nitrogen loading or recharge volume equalized on a per acre basis, or as a nitrogen concentration.

- The larger study area used in the MANAGE analysis encompassed a greater proportion of forest and wetlands, resulting in a lower total nitrate loading overall.

- The concentration of the treated effluent used in the models ranged from 15 to 26 mg/l in the Aldinger 2001 and 2000 models, respectively, to 46 mg/l for residential waste with conventional treatment and 30 mg/l for commercial waste with advanced treatment in the MANAGE model. This accounted for some of the differences in total nitrate loading to the study areas.

- The Aldinger (2000) model, which is most similar to MANAGE, uses a very low effluent nitrate concentration of 36 mg/l, based on conventional wastewater treatment, while also assuming a high denitrification rate of 25% with conventional treatment for a final concentration of 26 mg/l. This model also estimates a much higher groundwater recharge volume from

precipitation. Although some differences in assumptions tend to cancel each other out, the high recharge results in a large dilution factor, indicating that the final estimated nitrogen concentration of 5 mg/l is a low estimate.

4.2 Detailed Analysis

As is summarized below, minor changes in the model assumptions provide different export values. The final values should be viewed in terms of order of magnitude rather than an absolute value.

Paul B. Aldinger and Associates, Inc. (Aldinger) initially modeled the potential loading to groundwater using a mass balance approach in their July 2000 report. In this model the study area was taken from the area of the site Master Plan, 321.17 acres (figure 15). A mass balance model accounts for all hydrologic and nutrient loading from all land uses on the site. In the Aldinger model the nutrient and hydrologic loading from the Job Corps ISDS, a proposed office development (3,000 persons) and other sources were factored into the model. This model was similar in method and scope to the URI MANAGE model presented in this report.

In the MANAGE mass balance model the community well head protection area for the Phoenix House wells was selected as the study area to evaluate potential impacts to existing wells. This 521.8 acre site encompasses the well head protection areas for the two Job Corps wells. The MANAGE model applied nitrate-N loading estimates to groundwater recharge based on local research. The number of septic systems throughout the study area was based on the mapped residential density and land use type. In the proposed Ladd School development area the number of septic system serving current uses (Job Corps, Marathon House and fire fighters training area) was estimated and input directly into the model. These estimates are itemized in Appendix A. In all model scenarios for the Ladd School study area, the Job Corp's wastewater treatment system is assumed to be a denitrifying system, decreasing the nitrate entering the groundwater by 50% of the input value. The MANAGE model was used to analyze the current nutrient loading as well as two future development scenarios. The scenario Ladd 2 (future) is the closest to that of the Aldinger model. In the Ladd 2 scenario a 3,000 person office building was added into the calculations. In the MANAGE future scenarios all new ISDS are assumed to be denitrifying systems, therefore the future office park is assumed to be of denitrifying design. The Aldinger model assumes that all development will include the construction of conventional septic systems with a decrease in nitrate concentration of 25% before entering groundwater.

The MANAGE model estimates an average nitrate concentration in groundwater recharge of 3.3 mg/L NO3-N with the utilization of a denitrifying septic systems and 5.3 mg/L NO3-N with conventional septic systems (see App. B for all MANAGE assumptions). The Aldinger Report estimates that the loading will be 5 mg/L NO3-N with conventional septic systems. Although the estimated final concentrations of nitrate in groundwater recharge are similar between the models the nitrate loading from ISDS in the Aldinger report (6,139 lbs N/yr) is approximately half that of the nitrate loading from the MANAGE model for the conventional ISDS systems (pre-BMP value = 13,744 lbs N/yr). This may be related to the lower initial septic effluent value used by Aldinger. The loading of nitrate to groundwater in the Aldinger report (6,139 lb N/yr) is similar to the loading expected based on the URI MANAGE model after utilizing denitrifying ISDS (post-BMP = 8,274 lbs N/yr). Most of the nitrogen loading to groundwater in both models is due to wastewater, so the larger study area in the MANAGE report doesn't affect the total nitrogen loading value to a large extent. The slightly higher recharge value for the MANAGE model due to the larger study area dilutes the nitrate load so that the final nitrate concentration in groundwater is similar to the Aldinger model.

In June of 2001 Aldinger responded to a request from Miller Dyer Spears Inc. to model another area in the Ladd School complex (model 1a). The model utilizes the Draft RIDEM Method 1 for

the calculation of nitrate loading to groundwater from large ISDS systems. RIDEM Method 1 only estimates groundwater nitrate concentration based on the contribution of nitrate from a wastewater treatment system. Hydrologic terms include the infiltration of septic tank effluent and precipitation. The study area is defined as an area twice the width of the ISDS leach field with a length equal to the distance from the up gradient side of the property to the down gradient property line. This simple model does not include any other loading factors.

The report dated October 2001 was an update and further review of the assumptions made in the June 2001 analysis after discussions with RIDEM. RIDEM questioned the use of the 10 mg/L NO3-N level for septic tank effluent as well as the size of the of the infiltration area. Aldinger utilizes RIDEM Draft Method 1 for the calculation of nitrate levels in groundwater recharge in models 1b and 1c. In the October 2001 report there are three different model results. Model 1b and 1c utilize the same method as model 1a although the assumptions have changed. In models 1b and 1c the concentration of the septic tank effluent was increased as requested by RIDEM, although the average yearly precipitation was also increased over that of model 1a, infiltration of stormwater was modeled on the site (as discussed in the RIDEM letter) and the wastewater loading was decreased. Additionally, in model 1c Aldinger allowed for additional dilution of the ISDS effluent by using groundwater that is flowing through the site towards the down gradient wetland. Models 2 from the Aldinger October 2001 report are similar to that of the initial mass balance model. This study area is smaller and apparently associated with old the Job Corps Center, unlike the initial analysis that was for the entire Ladd School study area. The Model 2b indicates the lowest groundwater recharge nitrate concentration possibly because it has a lower nitrate load that Model 1b and 1c and a large amount of groundwater recharge volume.

Fuss and O'Neil reviewed the models described above and also calculated nutrient loading using the RIDEM Method 1 (Model 3). The loading factors and assumptions are similar to Aldinger's June 2001 model (Model 1a) although the wastewater volume is slightly lower and the nitrate concentration in the drainfield is higher, in the Fuss and O'Neil report.

Overall, the Fuss and O'Neil model (Model 3) reports the highest predicted nitrate concentration at the down gradient property line (11.05 mg/L NO3-N) of all the models predicting nitrate recharge concentration using RIDEM Method 1. The Aldinger model 1c predicts the lowest concentration 5.3 mg/L for the ISDS models, this model utilizes groundwater moving thought the site to further dilute nitrate concentrations. Based on a letter from EPA to RIDEM dated August 6th 2001 found in the Fuss and O'Neil June 2004 report, EPA recommended that a 5mg/L NO3-N maximum level be set at the property line to trigger action before reaching the 10-mg/L NO3-N state and federal drinking water standard. Most of the data indicates that this level would be reached upon development.

4.3 Modeling Summary

Models are approximations of reality that must be viewed as estimates of potential conditions. The quality of the data generated is based on the input assumptions. In addition, results are best used to compare relative differences among different scenarios rather than direct comparison with monitored data. All models used focus on sources of nitrogen as a drinking water contaminant and indicator of other dissolved pollutants in wastewater.

Modeling results for the Ladd School areas are within an order of magnitude. However, different assumptions within individual models used tended to cancel each other out, resulting in more consistent results overall than might be expected. Most models used the RIDEM permit limit for the Job Corps treated effluent of 15 mg/l, which represents a low level that might be achieved with optimum system management.

All models generate source estimates, without factoring in potential for nutrient uptake through natural processes, with only rainfall on the study area used to calculate nitrogen concentrations,

without dilution from surrounding groundwater areas. Both factors tend to generate conservative results. Factors that tend to underestimate results include low effluent concentrations, very high infiltration rates for rainfall in the Aldinger models, which represents almost a zero runoff and zero evapotranspiration situation, and lack of fertilizer input estimates for the plume analysis models (RIDEM Method 1). The Fuss and O'Neill estimates used more realistic infiltration rates for precipitation and refined the plume area using groundwater flow data, resulting in nitrate estimates that exceed EPA-recommended nitrogen levels at the property boundary and river edge. In addition, these consultants calculated that phosphorus concentrations are estimated to reach the river at concentrations that exceed safe levels and are likely to promote nutrient enrichment in downstream waters.

Figure 15. Areas Used as Model Boundaries for MANAGE Analysis and Approximate Area Used in Aldinger Models.

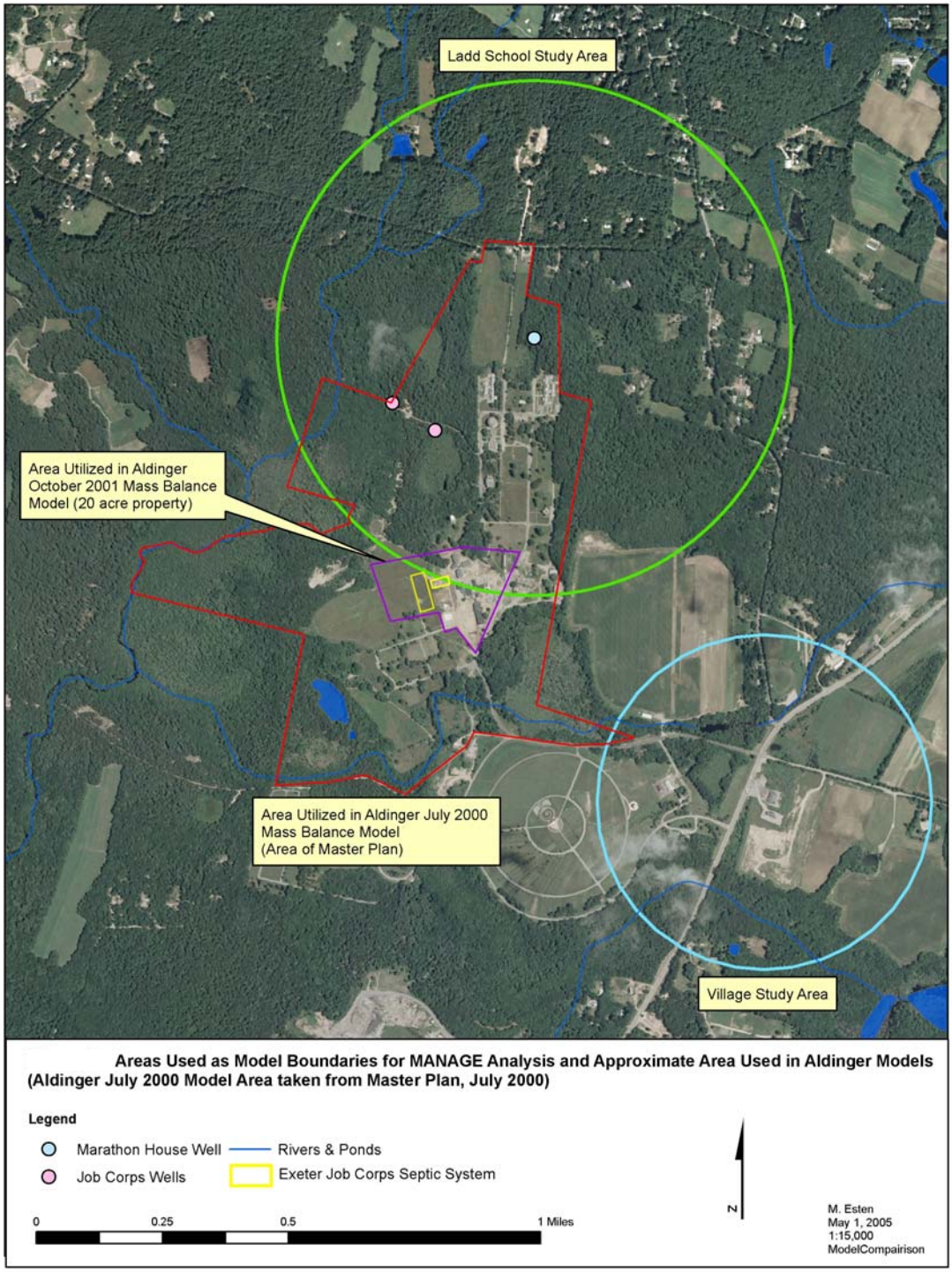


Table 6: Model Assumptions and Comparison

Comparison of Aldinger Mass Balance Model (July 2000) with URI MANAGE Model

Model Assumptions

PROJECT AREA	Aldinger Report (July 2000)[1,3]	URI MANAGE (Ladd Future Scenario)	Notes
Buildings (acres)	17.22		Estimates impervious surface based on RIGIS land use.
Parking lot (acres)	19.87		Refer to MANAGE technical documentation for percentage
Lot area to be irrigated (acres)	59.63		of impervious surface per land use.
Proposed paved roadways (acres)	2.83		
Wetlands and wetland buffers (acres)	132.37		
Greenspace (acres)	48.23		
Conservation land (acres)	11.08		
Ponds (acres)	0.36		
Job Corps land (acres)	22.61		
RIEDC/DOA land (acres)	6.97		
Town parcel (acres)	9.56		
Total Site Area (acres)	330.73		See figure 1 for the MANAGE and Aldinger study areas. Note that MANAGE used the Ladd School WHPA as the study area
Total Analysis Area[2] (acres)	**321.17**	**521.8**	

NITROGEN SOURCES	Aldinger Report (July 2000)[1,3]	URI MANAGE (Ladd Future Scenario)	Notes
Nitrate concentration in rainwater (mg/L)	0.5		MANAGE determines nitrogen load based on land use.
Avg. Nitrate in fertilizer application (lbs N/1,000 sq ft/yr)	3	4	
Fraction nitrate from fertilizer leached to groundwater	0.25	0.06	MANAGE lawn area is estimated based on land use. Aldinger assumes that specific land uses are fertilized.
Percentage of lawn area to be fertilized	100%	75%	
Septic System Effluent nitrate loading (ppm)	35	46	MANAGE estimates concentration of nitrate in residential septic tanks based on: 7.0 lb N/person/year, 50 gallons H20/person/day and 2.4 persons/ISDS. Actual data indicate that nitrogen concentration in septic tank effluent averages 60 mg/L (USEPA Onsite Wastewater Treatment Systems Manual, EPA/625/R-00/008, USEPA Office of Water, 2002). Concentrations in commercial units can be much higher (Higgins, J and T. Groves. 1999. Nitrogen Loading from Non-Residential Facilities. NOWRA Proceedings, pg 137).

NITROGEN LOADING	Aldinger Report (July 2000)[1,3]	URI MANAGE (Ladd Future Scenario)	Notes
Fraction of ISDS Effluent N leached to GW	75%	90%	
RIEDC/DOA ISDS (GPD)	800		
Job Corps Facility ISDS (GPD)	16,000	24,000	
New Office Development (3000 jobs) ISDS (GPD)	60,000	45,000	
Other (Residential development, Marathon house, etc.) (GPD)		8,050	
Avg. total sewage (ISDS) loading (GPD)	76,800	77,050	
Avg. total sewage (ISDS) loading of Nitrate to GW (lb N/yr)	**6,138.5**	8,274	BMPs applied (Denitrifying septic systems)
		13,744.1	Pre-BMP (Denitrifying septic system is not applied)

HYDROLOGIC LOADING	Aldinger Report (July 2000)[1,3]	URI MANAGE (Ladd Future Scenario)	Notes
Average rainfall (inches/yr)	48.81	45	
Evapotranspiration (inches/yr)		18	
Avg. annual surface runoff (inches/yr)		5.8	
Avg. irrigation rate (inches/yr)	3.56		
Avg. GW recharge from ppt (kcf/yr)[4]	30,514	40,334	(21.2 inches) Aldinger model also takes irrigation into account
Septic systems (kcf/yr)[4]	3,747.5	5,628	(2.9 inches)

Runoff Coefficients

Aldinger model provides surface runoff and groundwater recharge coefficients for impervious and pervious areas as well as coefficients for irrigated pervious areas. Runoff and recharge are calculated for project areas by multiplying the precipitation value by the surface and groundwater recharge coefficients. In irrigated areas the recharge and runoff due to irrigation waters are calculated by multiplying the recharge coefficient by the amount of irrigation and then adding these values to those calculated for recharge and runoff due to precipitation.

The MANAGE model estimates runoff coefficients based on soil type and land use and then subtracts this value and evapotranspiration from the total precipitation value to obtain the groundwater infiltration value per land use and soil type.

SUMMARY	Aldinger Report (July 2000)[1,3]	URI MANAGE (Ladd Future Scenario)		Notes
		post-bmp	pre-bmp	
Total GW Recharge kcf/yr[4]	34,261.5	45,962	45,962	Even though areas are different still getting similar data because most of nitrate is from septic systems
Total Nitrate to GW (lb N/yr)	**10,700**	**9,536.8**	**15,006.9**	Post-BMP refers to application of a denitrifying septic system. Pre-BMP refers to no BMPs applied. URI Manage model assumed that all new ISDS and the Job Corps system were of denitrifying design. The Aldinger model assumes that the septic systems are all conventional.
Average nitrate concentration in GW recharge (mg/L)	**5**	**3.3**	**5.3**	

Notes:

[1] Geohydrological Report on Former Joseph H. Ladd Facility, Exeter, RI July 20, 2000 (PBA Project number 99056)

[2] Aldinger report used a total analysis area of 321.17 acres, this was the total site area (330.73 acres) minus the Exeter town parcel (9.56 acres).

[3] Model analysis based on available information. It was determined that in the Aldinger Model calculations that the units for total GW recharge should be kcf/yr instead of cf/yr as written.

[4] kcf/yr = 1000 cubic feet per year

Report	Aldinger June 2001 Model[4]	Aldinger October 2001 Model[5]	Aldinger October 2001 Model[5]	Fuss and O'Neil – June 2004 Report[6]	Aldinger October 2001 Model[5]	Aldinger (July 2000)	URI CE (2005)
Reference Number	**1a**	**1b**	**1c**	**3**	**2**	**4**	**5**
Method	**RIDEM Method 1**	**RIDEM Method 1**	**RIDEM Method 1**	**RIDEM Method 1**	**Mass Balance**	**Mass Balance**	**Mass Balance**
Study Area	Infiltration area for RIDEM Method 1 = 3,000 ft (width of GW mound from ISDS) x 100 ft (distance to property line along flow path) = 300,000 ft2 (6.89 acres) (area that is multiplied by precipitation to determine infiltration). This doesn't take into account up gradient infiltration of rainwater to dilute effluent.	Assumed that effluent plume would expand to two times the width of the drainfield over a distance equal to the width of the drainfield measured along the GW contours = area of 196,875 ft^2 (4.51 acres). This doesn't take into account up gradient infiltration of rainwater to dilute effluent.		5 acres (Infiltration area for RIDEM Method 1)	20 acres	321 acres (Ladd School Master Plan Area)	522 (Marathon House WHPA)
Method Modifications	Nutrient loading only from Job Corps ISDS & rainfall	Nutrient loading only from Job Corps ISDS & rainfall	Included nutrient loading from Job Corps ISDS, rainfall and used groundwater flowing under drainfields to allow for additional dilution of effluent. Estimated the amount of groundwater flowing under the drainfield using Darcy's equation as 3,367 ft3/day	Nutrient loading only from Job Corps ISDS & rainfall	Similar method to that of initial study in 2000.	See prior table for details	See prior table for details
Job Corps ISDS wastewater loading	24,580 GPD	22,140 GPD	22,140 GPD	22,140 GPD	22,140 GPD	16,000 GPD (sewage loading for total study area = 76,800 GPD)	24,000 GPD (sewage loading for total study area = 77,050 GPD)
Nitrate concentration in septic tank		31.8 mg/L NO_3-N	31.8 mg/L NO_3-N			35 mg/L NO_3-N	46 mg/L , with 65 mg/L NO_3-N; comm. and institutional uses in Ladd Village areas.

Report	Aldinger June 2001 Model[4]	Aldinger October 2001 Model[5]	Aldinger October 2001 Model[5]	Fuss and O'Neil – June 2004 Report[6]	Aldinger October 2001 Model[5]	Aldinger (July 2000)	URI CE (2005)
Reference Number	**1a**	**1b**	**1c**	**3**	**2**	**4**	**5**
Method	**RIDEM Method 1**	**RIDEM Method 1**	**RIDEM Method 1**	**RIDEM Method 1**	**Mass Balance**	**Mass Balance**	**Mass Balance**
Drainfield nitrate concentration – (Most models assume treated effluent following recirculating sand filter).	10 mg/L NO_3-N	15.0 mg/L NO_3-N	15.0 mg/L NO_3-N	15.0 mg/L NO_3-N	15 mg/L NO_3-N	26 mg/L NO_3-N (did not assume a denitrifying system would be installed. Assumed that 25% of initial nitrate concentration would be lost to N_2 gas as a result of denitrification in a standard ISDS)	23 mg/L, with 30 mg/L NO_3-N (for Job Corps and future development in study areas where advanced treatment is assumed.
Total GW recharge volume	4.99×10^7 L/yr (13.0 MG/yr)	5.58×10^7 L/yr (14.5 MG/yr) Note: Groundwater recharge includes storm drainage for 3.1 acres on site. It is assumed that 90% of precipitation falling on this area becomes groundwater recharge.	9.06×10^7 L/yr (23.6 MG/yr) Note: Includes storm water drainage as model 1b	4.26×10^7 L/yr (11.1 MG/yr)	3090.2 kcf/yr (8.75×10^7 L/yr) (22.8 MG/yr) Note: Includes recharge from infiltration of stormwater from 0.1 acres of land.	34,262 kcf/yr (9.7×10^8 L/yr) (252.2 MG/yr)	45,962 kcf/yr (1.3×10^9 L/yr) (338 MG/yr)
Sewage infiltration area	45,000 ft^2 (area of leachfields)	45,000 ft^2 (area of leachfields)	45,000 ft^2 (area of leachfields)			NA	NA
Fertilizer use	Assumed none used	Assumed none used	Assumed none used			3 lbs N/ 1000 ft^2/yr	4 lbs N/1,000 ft^2/yr
Average rainfall	45 inches/yr	48.81 inches/yr	48.81 inches/yr	45.12 inches/yr	48.81 inches/yr	48.81 inches/yr	45 inches/yr
Concentration of nitrate in rainwater	0.5 mg/L (In the RIDEM Method 1 methodology 100% of the nitrate enters groundwater, but only 50% of the precipitation is recharged, this makes the actual GW recharge concentration 1.0 mg/L NO_3-N.)			1.00 mg/L NO_3-N (as per RIDEM Method 1)	0.5 mg/L NO_3-N	0.5 mg/L NO_3-N	N load based on land use
Total Nitrate to groundwater	**3.55×10^8 mg/yr NO_3-N (783 lb/yr NO_3-N)**	**4.78×10^8 mg/yr NO_3-N (1054 lbs/yr NO_3-N)**	**4.78×10^8 mg/yr NO_3-N (1054 lbs/yr NO_3-N)**	**4.71×10^8 mg/yr NO_3-N (1038 lb/yr NO_3-N)**	**821.1 lb/yr NO_3-N**	**10,700 lb N/yr**	**9,537 lb N/yr (with BMPs)**
Average nitrate concentration at the property line (100 ft from edge of leachfield)	**7.13 mg/L NO_3-N**	**8.6 mg/L NO_3-N**	**5.3 mg/L NO_3-N**	**11.05 mg/L NO_3-N**			

Report	Aldinger June 2001 Model[4]	Aldinger October 2001 Model[5]	Aldinger October 2001 Model[5]	Fuss and O'Neil – June 2004 Report[6]	Aldinger October 2001 Model[5]	Aldinger (July 2000)	URI CE (2005)
Reference Number	**1a**	**1b**	**1c**	**3**	**2**	**4**	**5**
Method	**RIDEM Method 1**	**RIDEM Method 1**	**RIDEM Method 1**	**RIDEM Method 1**	**Mass Balance**	**Mass Balance**	**Mass Balance**
Average nitrate concentration discharging to the river				**8.5 mg/L NO_3-N**			
Concentration of nitrate to groundwater (GW recharge)					**4.3 mg/L**	**5 mg/L**	**3.3 mg/L**

[4] Aldinger and Associates, Inc. Nitrate Loading Study for the Proposed Job Corps Center, Exeter, RI June 2001 (PBA number 00112-1)
[5] Aldinger and Associates, Inc. Supplemental Nitrate Loading Study for the Proposed Job Corps Center, Exeter, RI, October 2001
[6] Fuss and O'Neil. Job Corps Hydrologic/Water Quality Review, Town of Exeter, Exeter, RI, June 2004.

5.0 SUMMARY FINDINGS

5.1 Interpreting Assessment Results

Determining the effects of changing land use is an inexact science at best. Data gaps on the fate and transport of pollutants, variability in the natural environment, and uncertain effects of contaminants on highly sensitive habitat all complicate efforts to define an optimum development capacity. Accidental spills, improper use and disposal of hazardous or environmentally harmful materials introduce risks that are impossible to quantify. Because of these unknowns, even complex models incorporating extensive field data may generate inconclusive results. Simplified assessment methods, such as those used in this analysis and in previous modeling studies, generate approximate information on the type and relative magnitude of pollution sources to support land use decisions. However, understanding the limitations of these methods is necessary to properly interpret results.

- **Results are estimates, best used for comparison.** Results are most useful in identifying the most serious pollution risks and in comparing the relative change in nutrient loading with different land use intensities or pollution control practices. Because results are approximate, they are best used to compare differences between estimated current conditions and future projections.

- **Output based on inputs and assumptions.** Results of any model are only as reliable as the input data and assumptions on which they are based. For example, more extensive information is available for nitrogen sources. Estimates of nitrogen inputs therefore tend to be most reliable while estimating the amount likely to reach a nearby well, property boundary or surface water body is more uncertain. Because of this uncertainty MANAGE nutrient loading estimates represent sources entering groundwater recharge or surface runoff, without taking into account uneven mixing in groundwater or natural uptake.

- **Nitrogen used as one indicator.** Nitrogen is a drinking water contaminant and an indicator of other dissolved pollutants associated with wastewater and fertilizers. For the most part, many other pollutants and stresses that might impair water quality have not been evaluated. These include for example, sediment and phosphorus in stormwater runoff, pesticides that might be applied improperly, or solvents and fuel that might enter groundwater through spills or improper disposal.

- **Land use decisions are based on values.** The value of local water resources and need to protect high water quality are key factors that directly influence the level of risk that local officials might be willing to accept with land development. Under Rhode Island Enabling legislation, town values and priorities are established as goals and policies of the Comprehensive Community Plan, providing the legal basis for land use decisions. However, town plans may set competing goals for other important needs, such as economic development or affordable housing. As a result, the choice between preserving groundwater supplies and achieving other town goals becomes a matter of local values and priorities. Where impacts are uncertain, local officials may be more willing to accept some risk of water quality impact depending on the level of public support for drinking water protection vs. other public values such as economic development or affordable housing.

5.2 Ladd School Pollution Risk Assessment

Summary findings for the Ladd School area are organized according to the range of risk factors commonly used to evaluate potential impacts to water quality. These factors include:

- value of the resource
- need to protect high water quality
- existing water quality conditions and sensitivity to impact;
- potential sources of pollution;
- risk of pollutant transport and contamination
- management measures to avoid or minimize impacts.

The MANAGE assessment and previous studies tend to focus on two of these factors – the potential sources and transport of pollutants. Yet, all factors are relevant in making decisions about future use of the Ladd School site, and provide a logical outline for organizing our findings.

This summary of the Ladd School assessment incorporates findings of the MANAGE assessment, GIS map analysis, and our review of previous nutrient loading analyses. This is followed by a brief overview of the MANAGE assessment findings for the Route 2 Alternative Development Scenario.

5.2.1 Value of the Resource to the Town

Groundwater resources

The Ladd school site overlies the Queens River groundwater aquifer, including the portion of the aquifer mapped as the groundwater "reservoir" having the deepest sand and gravel deposits and groundwater storage capacity. This reservoir is considered the most productive area for high-yield public wells.

The Queens River groundwater reservoir is one of the few groundwater reservoirs within Exeter not protected as open space that may be available to the town for water supply.

The Job Corps wastewater treatment system is currently located in the center of the groundwater reservoir, eliminating this site and surrounding area from use as a future water supply.

Additional development in the Ladd School area reduces the land available for future water supply because of the relatively large setbacks required between a public well and any developed land, and especially between a public well and a large onsite wastewater treatment system. The protected area surrounding a public well ranges from 11 acres to 100 acres, depending on setbacks to wells of 400 to 1,200 feet.

Queens River

- The Queen's River, considered one of the most pristine rivers in the state, is a regionally significant habitat for diverse and rare aquatic species that depend upon clean, cold, running water.

- Because of it's pristine condition and habitat sensitive to human disturbance, RI Audubon has invested in the Marion Eppley property as the largest of its 15 refuges, and the only one not open to the public. Instead, it is maintained as an unspoiled and unbroken tract for wildlife habitat and study.

- The Nature Conservancy, the Rhode Island Audubon Society, and the RI Department of Environmental Management have made acquisition of land and easements in this watershed a top priority in the State and region, with significant support by private donations and federal grants. Collectively, land acquisition to protect the Queens River represents a significant investment of public and private funds. The possibility that further development at the Ladd School site will conflict with and diminish the value of this public investment is a serious concern which should be evaluated.

5.2.2 Water Quality Goal - Need to Protect Existing High Water Quality

- Exeter's groundwater resources are classified by RIDEM as the highest possible (GAA), and suitable for drinking water supply without treatment. In addition, these are EPA-designated "sole source" aquifers, meaning there are no other options available to the community. Each designation warrants the highest level of protection.*

- Maintaining high quality waters will ensure that groundwater resources are available for future supply if needed, and without water treatment which can be costly and impair taste and odor.

- Nitrogen in groundwater is a concern because it is a drinking water contaminant, with a preventative action level of 5 mg/l nitrate-N. At much lower levels, nitrogen is also a sign that wastewater and fertilizers are entering groundwater, increasing the risk that other associated pollutants such as bacteria, solvents and pesticides may be entering groundwater.

- Because of its unique value, the RIDEM has designated the Queens River as "Special Resource Protection Waters" where no measurable degradation is allowed. The rare and unique aquatic species found here are considered highly sensitive to relatively small changes in pollutants levels at concentrations well below drinking water standards. However, the exact impact thresholds are unknown and specific water quality criteria have not been set.

**NOTE: RIDEM sets a "Preventative Action Limit" for drinking water quality of 5 mg/l nitrate-N, which is 50% of the groundwater quality standard. Other states have comparable standards or lower. For example, the state of Washington establishes an anti-degradation standard of 2 mg/l nitrate-N in groundwater. Vermont's goal for GAA waters is to support land use activities that "ensure no exposure to risk".*

5.2.3 Existing Water Quality Conditions and Sensitivity to Impact.

Groundwater

Groundwater quality is very good overall, and public wells are meeting all drinking water standards. Monitoring shows that some wells and shallow groundwater in the vicinity of the Job Corps site have slightly elevated nitrate-N levels from fertilizers and /or wastewater effluent.

Queens River

Watershed Watch monitoring at several sites in the Queens River system from 2000 to 2003 indicates that the average concentration of total phosphorus is low, typical of a healthy stream system.

5.2.4 Potential Sources of Pollution

Estimated Nutrient Loading from Onsite Wastewater Treatment - URI MANAGE assessment and previous studies

Nitrogen inputs to groundwater recharge in the Ladd School wellhead protection area are expected to double with the future development scenario. The estimated concentration of nitrate-N entering groundwater recharge is 3 mg/l, considered a moderate risk; however, this is an average for the entire wellhead protection area. In reality, pollutants will be concentrated at much higher levels in effluent plumes from onsite wastewater treatment systems, increasing localized pollution risks to nearby wetlands and surface waters. *Source: URI MANAGE*

Using a wastewater plume analysis, the consulting firm of Fuss & O'Neill concluded that the nitrogen concentration from the existing Job Corps onsite wastewater treatment system will exceed the drinking water standard of 10 mg/l at the property boundary, and that the preventative drinking water action level of 5 mg/l will be reached at the Queens River.

Hydrologic and nutrient loading assumptions used in the Fuss & O'Neill plume analysis are generally consistent with those used in the URI MANAGE assessment except that we assume a higher concentration of nitrogen in the treated effluent based on literature values and URI monitoring of small scale demonstration systems. The Fuss & O'Neill report and previous studies all assume that the Job Corps treatment facility will meet the required RIDEM discharge limit of 15 mg/l total nitrogen. Because achieving this standard would require optimum performance of the treatment facility – and supporting monitoring data was not available – modeled estimates using the 15 mg/l nitrogen standard may underestimate actual nitrogen loading.

The advanced onsite wastewater treatment system at the Job Corps site is not designed to remove phosphorus– the key nutrient likely to degrade fresh water aquatic habitat due to excessive growth of algae and weeds. The consulting firm of Fuss & O'Neill estimated that phosphorus – which is discharged in effluent at approximately 1000 times the 25 ppb DEM standard for lakes, will eventually reach the river in concentrations exceeding safe standards.

Modeling results for the Ladd School area using the URI MANAGE method and previous studies are within an order of magnitude. Different assumptions within individual models used tended to cancel each other out, resulting in more consistent results overall than might be expected. Most models used the RIDEM permit limit for the Job Corps treated effluent of 15 mg/l, which represents a low level that might be achieved with optimum system management.

Potential Future Impacts

Under the future scenario, wastewater effluent is expected to account for approximately 80% of the nitrogen entering groundwater, making proper operation and maintenance of wastewater treatment systems the single most important management priority. *Source: URI MANAGE*

The future scenarios consider only expanded use of the Ladd school site itself, without accounting for new development on non-institutional land within the wellhead. Future pollutant inputs from development-related runoff and wastewater discharges may therefore be greater than estimated.

Future pollution risks are based on very general information about potential wastewater flows. We were unable to obtain information on current or planned activities or waste that might be generated.

Wastewater Characteristics

Wastewater from institutional facilities such as Job Corps facility is much more difficult to treat than domestic wastewater from individual systems, requiring additional precautions to ensure proper system function.

- Wastewater from kitchen facilities is notoriously difficult to treat due to: high biochemical oxygen demand (BOD); total suspended solids (TSS); concentrated fats, oil and grease; and peak flows.

- Laundry waste is extremely difficult to treat with onsite systems. As a result, RIDEM ISDS regulations prohibit new commercial laundry discharges in unsewered areas.

- High failure rates due to high flow and high-strength waste from institutional facilities led URI researchers, in cooperation with State agencies, to select state-owned community living centers as research sites in a new study of remediation methods for large drainfields.

Wastewater Treatment Complexity

Advanced treatment systems with pumps, mechanical and electrical components, require frequent inspection and maintenance by a qualified maintenance provider. In particular, large-flow systems require regular monitoring and operational adjustments to achieve optimum performance.

Estimated Impervious Cover and Runoff

The amount of pavement and other impervious cover is an indicator of pollution risk with land development. The estimated impervious cover for the entire Ladd School wellhead may exceed the 8 percent level considered safe for highly sensitive aquatic habitat such as the Queens River. However, 50 percent of the imperious cover is concentrated in the Ladd School area, increasing the potential for localized runoff impacts to the nearby Queens River and associated wetlands.

Water Withdrawals

Low streams flow due to current and future water withdrawals is a serious concern in the Queens River and a subject of U.S. Geological Survey investigations.

5.2.5 Risk of Pollutant Transport and Contamination.

Impacts of Current Land Use

- Existing drinking water wells at the Ladd school site are considered at low risk of impact from the Job Corps wastewater treatment system given that the leachfield is located on the outer edge of the combined Phoenix House /Job Corps wellhead protection area. Potential impacts from the Phoenix House wastewater treatment were not evaluated.

- According to previous studies by Fuss & O'Neill, effluent from the Job Corps leachfield is expected to reach the Queens River at the drinking water action level of 5 mg/l, and exceed the maximum drinking water standard of 10 mg/l at the property boundary; phosphorus is expected to reach the Queens River at concentrations exceeding safe standards, resulting in nutrient enrichment of aquatic habitat;

- Groundwater in the vicinity of large-flow wastewater treatment systems is at risk of contamination from spills or improper disposal of wastes to the ground surface or directly to groundwater via onsite wastewater treatment systems.

Future Impacts to Water Resources

- New or expanded wastewater treatment systems required with more intense development are expected to increase the risk of localized groundwater contamination. Since new onsite system locations have not been identified, the potential for effluent movement to wells and surface waters is unknown.

- Increased stormwater runoff with new development concentrated in the Ladd School area, is expected to increase stormwater pollutants, reduce groundwater recharge, and affect natural pollutant removal function. Actual impacts are uncertain and will depend on development location and stormwater management practices used.

5.2.6 Management Measures to Avoid or Minimize impacts.

State Regulations Set Minimum Standards

RIDEM regulations for freshwater wetlands, stormwater management and onsite wastewater treatment set minimum standards, which may not be adequate to protect sensitive habitat. In addition, these are not designed to control cumulative impacts with future development. To better protect local water resources, many Rhode Island municipalities set stricter standards to protect critical water resources.

RI DEM stormwater standards are being updated and do not currently incorporate improved methods for nutrient removal, volume control, and use of nonstructural controls.

Local Authority Over Use and Management of the Site

In collecting information about use of the Ladd School site for this assessment, we found great uncertainty about current activities, future uses, and types of materials that might be used, stored or disposed of in this aquifer recharge area. The lack of information available to town officials about use and management of the site raises serious concerns about municipal capacity to ensure that appropriate management practices are applied to protect groundwater quality.

Without local oversight, it is unclear who is responsible for ensuring that good pollution prevention practices are used. For example, recommendations of previous assessments to limit fertilizer use and to design stormwater systems to promote infiltration do not appear to have been implemented.

Wastewater Management

RI cities and towns are responsible for proper maintenance of onsite wastewater treatment systems. However, the town lacks a wastewater management program to ensure that onsite systems are regularly inspection and properly maintained.

Without local oversight, it is unclear who is responsible for reviewing wastewater treatment performance data and enforcing maximum discharge limits. We requested, but were unable to obtain system monitoring data from the Exeter economic development commission, Atlantic Solutions, the firm hired to maintain the Job Corps system, and Brian Thalmann, the system designer. This gap in reporting monitoring data is a serious concern since maintenance providers need performance results to adjust system function for optimum treatment efficiency. Obviously, the town is also unable to determine compliance with monitoring standards without data reporting.

Lack of information about current or projected wastewater characteristics raises concerns about treatment system function and potential groundwater impacts. In addition, training activities may increase risk of spills or improper disposal of wastes unless training incorporates effective education on use of good pollution prevention practices, with close supervision.

5.3 Assessment of Alternative Development – Village Study Area

5.3.1 Potential Benefits of a New Village Center

Directing new growth from the Ladd School site to nearby Rt. 2 offers the opportunity to create a new community growth center with direct highway access and visibility. The “village study area”, as it is referred to in this analysis, is located in an existing highway commercial zone, consistent with town planning goals. This location could attract mixed use commercial development while meeting residential housing needs such as elderly and low-income housing. The town’s interest in redirecting development to this site is based on the following considerations:

- Good community development and economic growth strategy. High density, compact development makes efficient use of land, water and wastewater utilities that reduces construction cost. Direct highway access improves marketability to investors.

- Concentrating development in compact centers preserves surrounding open space to maintain farmland, fields and woods that give Exeter its distinctive character. More innovative techniques can be used to direct new development from existing farmland and forest to the new center using methods such as transfer of development rights. The town plan supports and encourages these concepts which relate to economic development, affordable housing, open space, and protection of drinking water and environmental resources.

- With public water provided by nearby Ladd area wells, the site could support higher density, efficiently designed within a small area while preserving surrounding open space in keeping with Exeter’s rural character.

- Redirecting growth from Ladd School to this site removes new development from the Queens River groundwater reservoir, thereby protecting one of the few available areas for high-yield wells to meet future water supply needs.

- Highly treated wastewater can be dispersed to leachfields located on the outer edges of the Queens River aquifer, thus maintaining groundwater recharge. The greater distance to the groundwater reservoir provides longer travel time with opportunity for additional wastewater treatment via natural processes before effluent reaches either he most productive portion of the aquifer or the Queens River.

- New development could be located at least partly outside the Queens River watershed, within the Chipuxet River watershed, where aquatic habitat is considered much less sensitive to human impacts.

5.3.2 Summary Findings – Village Study Area

To evaluate the environmental impacts of development at this alternative location we conducted a pollution risk assessment using the MANAGE method, similar to the analysis of the Ladd School site. The alternative development scenarios are purely hypothetical but the proposed development intensity and wastewater loading is comparable to current and future development at the Ladd School site. The hydrologic and nutrient loading analysis assumes that all development would be located within the wellhead protection area serving the existing highway commercial development. This represents a worst-case estimate of impacts to groundwater. It is more likely that new development and wastewater treatment systems would be constructed at least partly outside the wellhead protection area; or, the wellhead may be eliminated entirely if public water is brought in from the Ladd School wells and existing businesses agree to connect.

Water Quality Goals

The Village wellhead protection area is located on the edge of the Queens River watershed, outside of the groundwater reservoir considered capable of supporting high-yield wells, but partly within the groundwater aquifer recharge area. Portions of the site outside of the Queens River watershed are located within the Chipuxet River watershed where the water quality goal is to protect swimming and fishing use, particularly in the recreational lake immediately downstream of the site; and to protect groundwater resources.

Downstream river segments and 100 Acre Pond are impaired due to excessive nutrients and low water flow. To maintain and/or restore these water resources, management priorities are to control runoff volume and maintain infiltration, treat runoff to reduce phosphorus and sediment, and prevent degradation of groundwater by toxics and elevated nitrogen.

Impervious Cover and Stormwater Runoff

Impervious cover with future development is estimated to increase from 3% under current conditions to 20% with development comparable to current use of the Ladd School area, and up to 36% with more intensive use equivalent to future use of the Ladd school site. The later is considered an extreme risk to nearby streams. However, this assumes a worst-case scenario where all new development is sited within the existing wellhead protection area and conventional development practices are used. Impacts would be less if portions of the new development are located outside the wellhead protection area.

Setting a maximum impervious limit of 40% for the new high intensity development in this study area is estimated to reduce the average impervious cover for the wellhead protection area from 36% to 20%, and reduce it further to 13% with a maximum limit of 25% impervious for new development.

Estimated Nitrate Loading to Groundwater Recharge, Village Area

In all future village scenarios, the primary source of nitrate-N to groundwater is expected to shift from agricultural fertilizers to septic systems, underscoring the need for proper system siting, treatment and maintenance.

Average nitrogen concentrations entering the wellhead protection area are estimated to increase to 3.6 mg/l nitrate-N with future development equivalent to current use of the Ladd School site, and up to 8.6 mg/l nitrate-N with more intense development comparable to the future use of the Ladd School site. In both cases 50% nitrogen removal is assumed for new development. Any increase above the 5 mg/l nitrogen is ranked as a high risk, however, this represents a worst-case scenario with all onsite systems located within the wellhead protection area.

Several management options are available to reduce potential impacts of onsite systems to groundwater quality. These include: locating wastewater treatment systems at least partly outside of the watershed; promoting infiltration of stormwater runoff to reduce the concentration of nitrogen recharging groundwater; and selecting an advanced treatment technology capable of reducing total nitrogen by more than 50%, and providing advanced treatment of phosphorus.

Modeling results suggest that stormwater management measures designed to control runoff volume can maintain groundwater recharge while also diluting nitrogen inputs near the moderate level of 5 mg/l. However, more aggressive controls, such as keeping impervious cover below 25% for commercial development, and maintaining recharge volume as close as possible to pre-development levels appear to be most effective in keeping nitrogen concentrations near moderate levels.

Estimated nitrogen inputs are average values for the wellhead protection area. Wastewater plume analysis is needed to better evaluate potential impacts from onsite wastewater treatment systems that might be located in this area, and to establish appropriate setbacks from surface waters, wetlands, and wells.

Proper use, operation and maintenance of any advanced wastewater treatment system are essential and are best assured through a municipal wastewater management program. This is equally important in the village study area as in the Ladd School site.

6.0 RECOMMENDATIONS

The recommendations outlined in this section are based on assessment findings and incorporate current, widely accepted standard management practices for controlling development impacts, including voluntary management standards for onsite wastewater treatment systems developed by EPA (2003) and others. These recommended actions address the range of risk factors outlined in the summary findings of the previous section, but focus on the most serious risks identified. Because the town of Exeter has primary authority to regulate land use and the responsibility to control associated impacts to water resources in the study areas, many of the suggested actions are directed to town officials.

Drinking Water Protection

- Diverting future development from the Ladd School area to the Rt. 2 village study area will protect the Queens River groundwater reservoir as one of the few remaining areas within Exeter available for high-yield water supply wells.

- Intense development of the Ladd School area is incompatible with use of the site as a water supply and threatens highly sensitive aquatic habitat.

- With public water provided from the Queens River aquifer, the nearby Rt.2 village study site could support high density mixed use development, efficiently designed within a small area while preserving surrounding open space in keeping with Exeter's rural character.

- Given findings of this assessment and previous studies of the Ladd School area, the town should review goals and policies of the comprehensive community plan and update these as necessary to clearly identify priorities for protection of drinking water quality, critical aquatic habitat, and recommended standards to prevent degradation of these areas.

- Threats to groundwater from current activities and future development can be minimized by adopting up-to-date pollution control practices, as outlined below. In general, adopting local design, siting and maintenance standards that exceed state minimum requirements will provide a higher level of protection for critical groundwater supplies and sensitive aquatic habitat.

Hazardous Materials

- In aquifer recharge areas and wellhead protection areas, the town should prohibit land use activities that use or store hazardous materials, as these introduce the risk of groundwater contamination through improper use, disposal, or accidental spills.

- Underground fuel storage tanks of any size should be prohibited.

- The town should establish or update local groundwater protection regulations for aquifer recharge areas with procedures for project review, development standards and reporting requirements.

Site Design and Wetland Buffers

- Locate new development, and particularly any new onsite wastewater treatment systems, outside of groundwater reservoir areas and where possible, beyond community wellhead protection area boundaries.

- At a minimum, keep development beyond the 400 ft. inner protected radius for public water supply wells and establish greater setbacks from large flow onsite wastewater treatment systems based on wastewater plume analysis, well pumping rates and location of wellhead protection areas.

- Maintain maximum setbacks from new development and onsite systems to increase travel time to wetlands and surface waters in order to keep estimated phosphorus concentrations at safe levels (< 26 ug/l or less) before reaching these resources.

- The town should establish local setbacks to wetlands and watercourses from land disturbance and construction that exceed RIDEM minimum requirements. The USDA Forest Service (Welsh, 1991) recommends minimum buffers of 95 feet to 185 feet in to protect water quality. URI researchers (Desbonnet and others, 1994) concluded that a buffer width of 200 to 250 feet wide is needed to reduce phosphorus and other pollutants by 80 percent. Many RI municipalities have wetland buffers of 150 feet.

- Although soils in both the Ladd School and village study areas are generally suitable for development, the town should restrict development on high water table soils (2- 4 feet) and prohibit new construction on severe high water tables (< 2 ft) due to the difficulty in controlling stormwater runoff from these sites and risk of improper wastewater treatment.

Onsite Wastewater Treatment

- The town should require advanced wastewater treatment for all new onsite wastewater treatment and repairs using technologies that meet, or preferably exceed, fifty percent total nitrogen reduction. Use of pre-fabricated wastewater treatment units, capable of achieving total nitrogen concentrations of 10mg/l or less, and total phosphorus concentrations of 15 mg/l (.015 ppb) are strongly recommended as a means to conserve water, maintain recharge, and protect water quality at both the Ladd School and village study areas.

- Wastewater reuse and recycling should be considered for major new construction, using treated wastewater for flushing within buildings or drip irrigation. At a minimum, shallow drainfields should be used to disperse wastewater within upper soils for additional pollutant renovation rather than conventional leachfields.

- The town should establish an anti-degradation standard for groundwater that allows only a limited increase in average groundwater nitrogen concentrations beyond background levels, such as 2 mg/l as an average for the property. In addition, the modeled concentration of nitrate-N in wastewater effluent plumes should not exceed the 5 mg/l preventative drinking water action level at the edge of property, any well, wetland, or surface waterbody. Groundwater monitoring is needed to determine the existing background concentration. Future application of fertilizers should also be factored in to estimated loading.

- Any modeled nutrient loading analysis represents an approximate estimate indicating the magnitude of risk to wells, with uncertainty due to groundwater flow paths, the area assumed to provide dilution, actual treatment performance, and many other factors. As a result, the RIDEM setbacks from onsite system of 100 feet from private wells and 400 feet from public wells should be considered minimum, with larger buffers warranted from large flow onsite systems using results of the plume analysis as a guide.

- The town should prohibit or restrict new activities in the Ladd School area that generate high-strength waste which complicate wastewater treatment and increase risk of wastewater treatment system failure, such as restaurants and laundry facilities. If such uses are allowed, more stringent requirements for pre-treatment, maintenance, monitoring and contingency planning should be mandated.

- Existing high-flow, high strength wastewater discharges should be placed on a regular inspection and maintenance schedule and if necessary, the system upgraded to improve performance.

Wastewater Management

- Establishing a local wastewater management authority is absolutely essential to ensure proper use, operation and maintenance of advanced wastewater treatment systems and other large flow systems. This will require a town staff person or contractor to track inspection results, conduct spot checks to ensure maintenance is properly conducted, review results of any required monitoring, and taking necessary enforcement action if standards are not met. Since the town does not currently have this capability, the town should consider establishing wastewater user fees to offset these costs.

- Because the Job Corps onsite wastewater treatment system is not designed to remove phosphorus and the Fuss and O'Neill study estimated that phosphorus concentrations will eventually reach the Queens River at unsafe concentrations, the Job Corps center should develop a contingency plan for enhancing wastewater treatment to remove phosphorus.

- Beginning immediately, the town should request that all monitoring data, inspection results and maintenance completed should be sent directly to the town and DEM. Such reports should include comments comparing monitoring data with required performance standards, with notes explaining maintenance conducted, issues related to system use and operation that may have affected system performance, and if necessary, steps planned to enhance effluent treatment.

- The town should require all large system owners to report any violation of treatment performance standards to the town and DEM within 24 hours of monitoring. If standards are exceeded (15 mg/l for the Job Corps system) inspection and monitoring frequency should be increased to a monthly schedule or more regularly and a remediation plan implemented until the system is in compliance.

- The town should establish procedures to ensure system inspection and monitoring results are routinely reported to appropriate local officials, including the town planner, conservation commission, planning board, economic development commission and town council.

- The town should coordinate with DEM to review results of treatment system performance and groundwater monitoring and ensure that corrective measures are taken as needed.

Stormwater Management

- The town should establish stormwater management zoning standards and land development regulations that exceed current RIDEM requirements to maintain annual runoff volume and groundwater recharge at pre-development levels. All redevelopment projects should be required to meet the standards to the maximum extent possible.

- Town stormwater management standards should require use of nonstructural and small-scale upland stormwater management methods to the fullest extent practical to reduce the volume of stormwater runoff and pollutants generated, with closed drainage systems and conventional retention basins used only as a last resort. Pre-treatment should be required before infiltration as necessary to protect groundwater, with infiltration practices avoided with contaminated runoff from high-use areas.

- Stormwater management systems located within with Queens River watersheds should be designed to remove at least 85% of the average annual load of phosphorus, using a "treatment train" approach with a sequence of treatment practices if necessary.

- New development should be designed to minimize site disturbance by establishing limits of disturbance close to building footprints and roadways. Nonstructural stormwater controls should be incorporated into initial site design.

- The town should establish maximum impervious cover limits for new construction and re-development at the Ladd school and village study areas. A maximum of 25% is recommended for both development sites. Wetlands should be excluded from the calculation of impervious area since these will generate runoff during periods of seasonal high water table.

- Permeable pavements or gravel surfaces should be used to meet maximum impervious limits and to control runoff volume, especially in overflow and low intensity parking areas. For more information on selecting alternative pavements see URI Nonpoint Education for Municipal Officials, publications at www.uri.edu/ce/wq/.

- Wherever possible, new development at the Ladd School site should be restricted to areas that have been previously disturbed rather than developing forest and fields that currently provide high infiltration to recharge groundwater.

- The town should require that all stormwater management practices have an approved maintenance plan, with maintenance reports provided to the town by request. The town should consider establishing a maintenance fee to offset town expenses in overseeing regular stormwater system upkeep.

- The draft updated RIDEM Stormwater Quality Manual may be used as a technical guide in selecting and designing stormwater management practices using current methods. www.dem.ri.gov/programs/benviron/water/permits/ripdes/stwater/index.htm Additional guidance on widely accepted nonstructural practices and runoff volume controls are also available through other updated state stormwater design manuals such as the *Connecticut Stormwater Quality Manual*, published by the CT Department of Environmental Protection, and by national sources including the Low Impact Design Manual, published by U.S. EPA and other guidance available through the Center for Watershed Protection and the Low Impact Development Center.

Sustainable Goals for Water Quantity

- Expanding development at either the Ladd School site or the village study area with water supplied by the Queens River aquifer has the potential to aggravate existing low-flow conditions during dry weather. State agencies and the town should use results of extensive flow modeling by the U.S. Geological Survey to set safe water withdrawal limits and avoid impacts to groundwater supplies, stream habitat and wetlands associated with the Queens River.

- Use of wastewater reuse and recycling systems, using treated water for flushing or drip irrigation should be considered for all new major construction, and required for any new high water users.

- With new construction and redevelopment, the town should restrict building envelopes and lawn area to minimize landscape care needs.

Pollution Prevention and Stewardship

- The town should work with site managers to establish policies for low-impact landscape care, using for example, minimal amounts of slow-release fertilizer, low-maintenance, drought resistant grass varieties, and sustainable plant species to avoid need for outdoor watering and pesticides.

- The town and site managers should develop an education program for residents and workers at the Ladd School site on basic pollution prevention measures, to include: proper use, storage and disposal of cleaning products; septic system care; and landscape maintenance practices. These topics should be incorporated into training programs at the Job Corps center.

- The relationship between pollution inputs and stressors to actual change in water quality is often impossible to define. When impacts do occur, they are often gradual, localized, or intermittent based on seasonal or annual patterns of rainfall and temperature. To monitor long term trends, existing stream and groundwater monitoring efforts should be reviewed and expanded as necessary to identify both long term trends and localized impacts of development. Results should be made regularly available to town boards and procedures established to trigger preventative action as needed to protect existing high water quality without degradation.

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